Patient-Reported Digital Health Data for Clinical Trial Reporting

Samuel Volchenboum, MD, PhD

March 22, 2018

University of Chicago

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES

CENTER FOR RESEARCH INFORMATICS
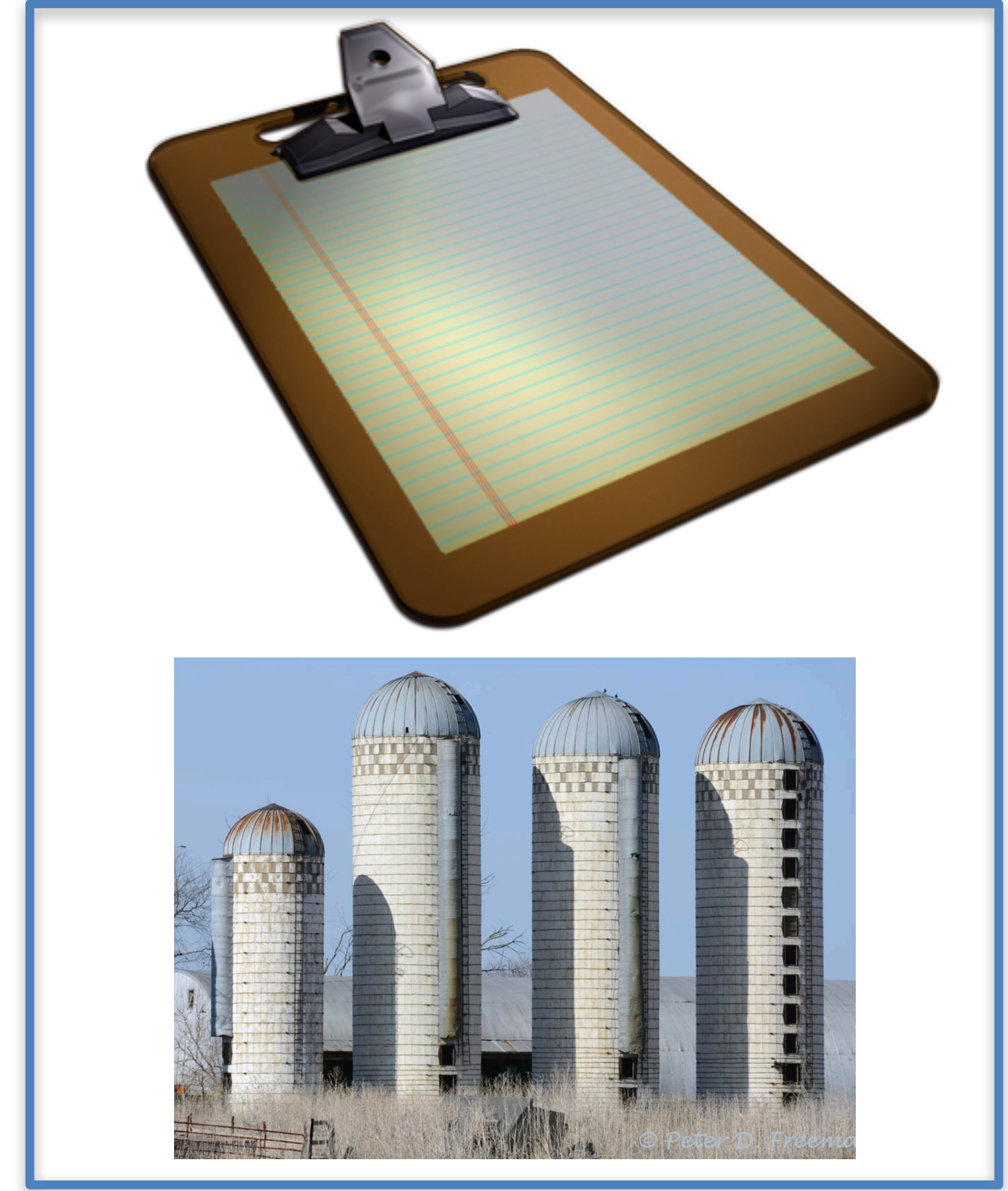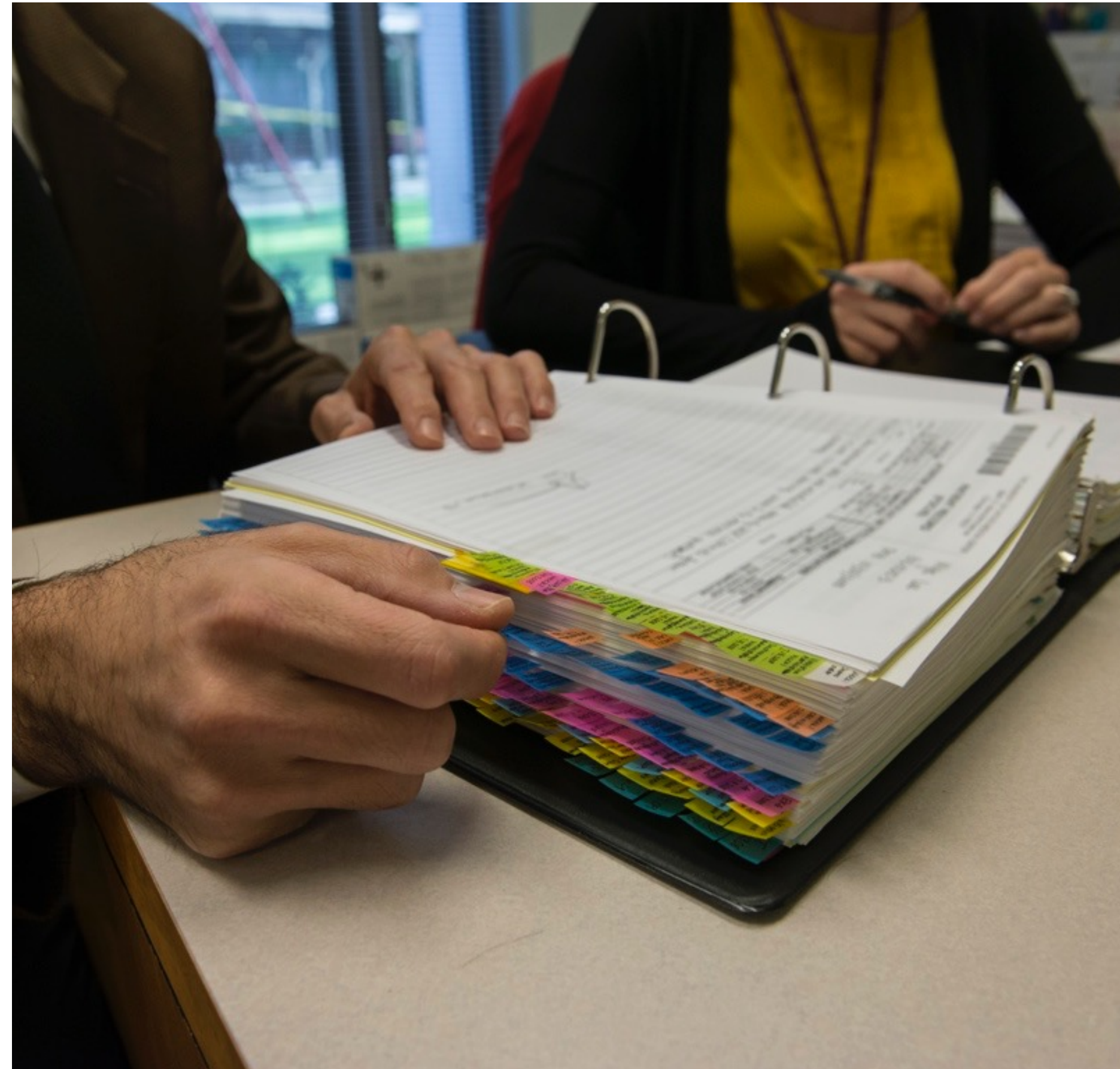
@samvolchenboum

LITMUS | HEALTH

Objectives

- **Understand** the landscape of consumer wearables, sensors, and devices in clinical trials

- **Appreciate** the caveats and opportunities of leveraging these devices for data collection as part of a clinical trial

- **Learn** why data standardization for wearables and sensors are key to acceptance and usage

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Clinical trials are broken

Example: Sleep data

The Pittsburgh Sleep Quality Index: A New Instrument for Psychiatric Practice and Research

Daniel J. Buysse, Charles F. Reynolds III, Timothy H. Monk, Susan R. Berman, and David J. Kupfer

Abstract. Despite the prevalence of sleep complaints among psychiatric patients, few questionnaires have been specifically designed to measure sleep quality in clinical populations. The Pittsburgh Sleep Quality Index (PSQI) is a self-rated questionnaire which assesses sleep quality and disturbances over a 1-month time interval. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of scores for these seven components yields one global score. Clinical and clinimetric properties of the PSQI were assessed over an 18-month period with "good" sleepers (healthy subjects, $n = 52$) and "poor" sleepers (depressed patients, $n = 54$; sleep-disorder patients, $n = 62$). Acceptable measures of internal homogeneity, consistency (test-retest reliability), and validity were obtained. A global PSQI score > 5 yielded a diagnostic sensitivity of 89.6% and specificity of 86.5% (kappa $= 0.75$, $p < 0.001$) in distinguishing good and poor sleepers. The clinimetric and clinical properties of the PSQI suggest its utility both in psychiatric clinical practice and research activities.

Name:_____   Date: _____

Pittsburgh Sleep Quality Index (PSQI)

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. **Please answer all questions.**

1. During the past month, what time have you usually gone to bed at night? _____
2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night? _____
3. During the past month, what time have you usually gotten up in the morning? _____
4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.) _____

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe:				
6. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?				
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?				

	No problem at all	Only a very slight problem	Somewhat of a problem	A very big problem
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				

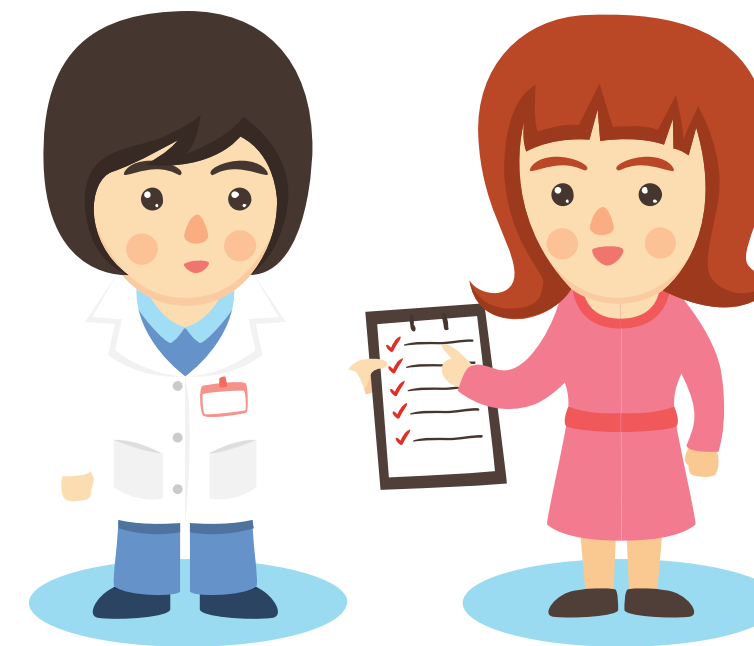|	Very good	Fairly good	Fairly bad	Very bad
9. During the past month, how would you rate your sleep quality overall?				

Example: Sleep data

Doctor conducts research study

>
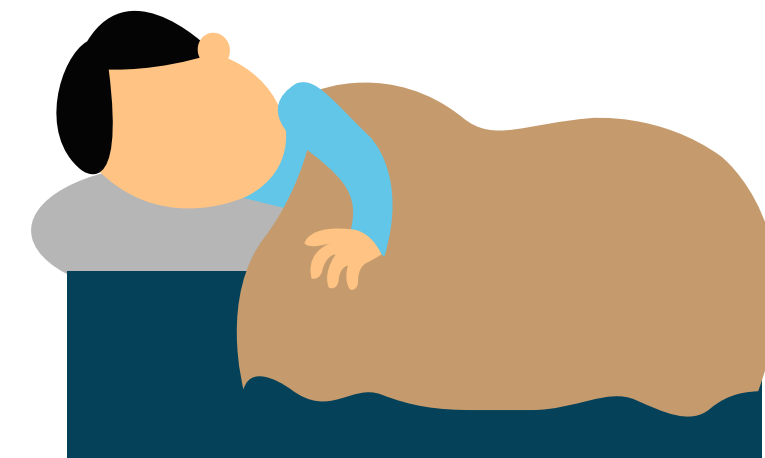
Sleep is an important quality-of-life metric

>

Sleep data collected every two weeks through a survey
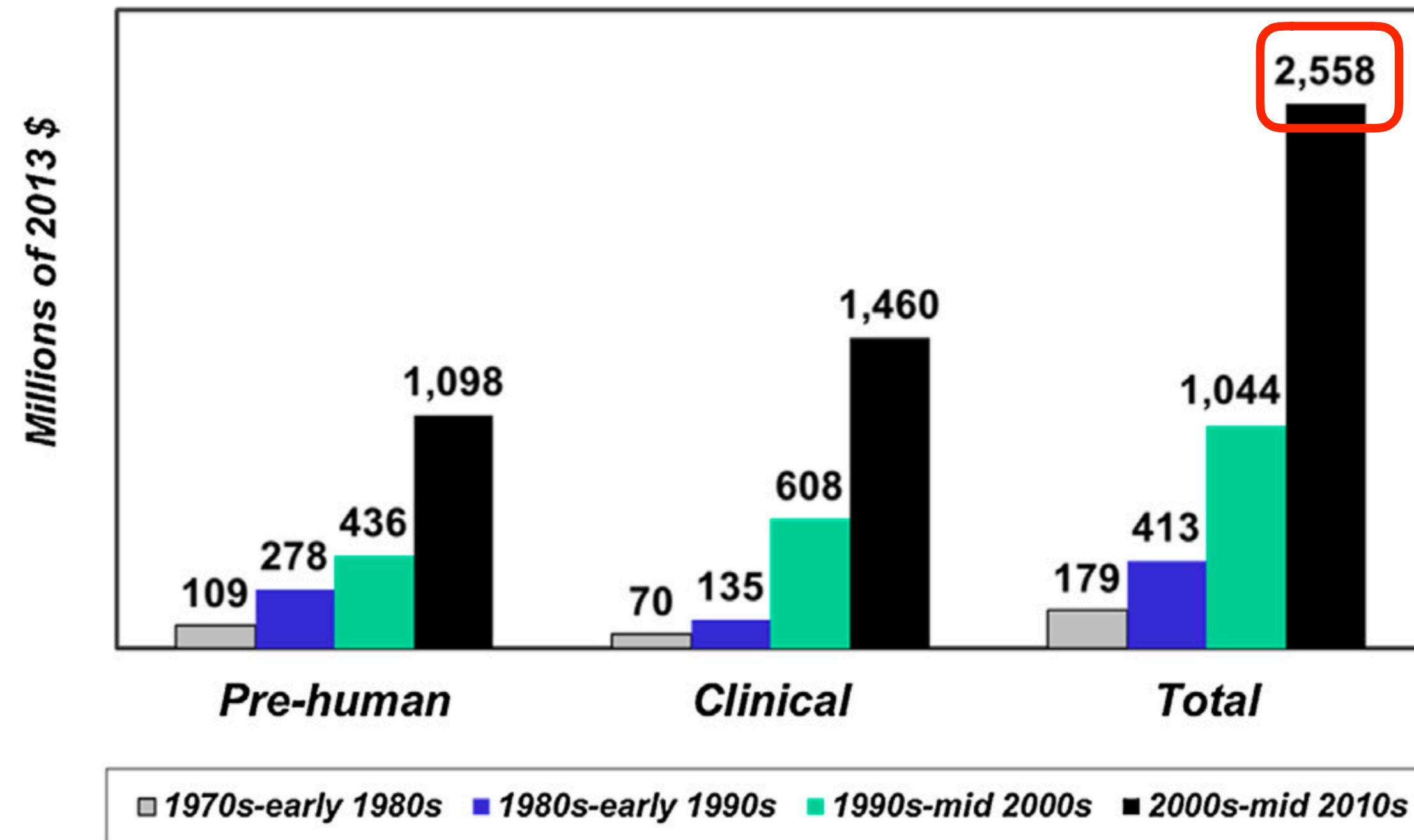
>

Data are unreliable

designed by freepik.com

$2.5 billion to develop a new drug

J.A. DiMasi et al. / Journal of Health Economics 47 (2016) 20–33 21

$2.5 billion to develop a new drug

J.A. DiMasi et al. / Journal of Health Economics 47 (2016) 20–33 21

$2.5 billion to develop a new drug
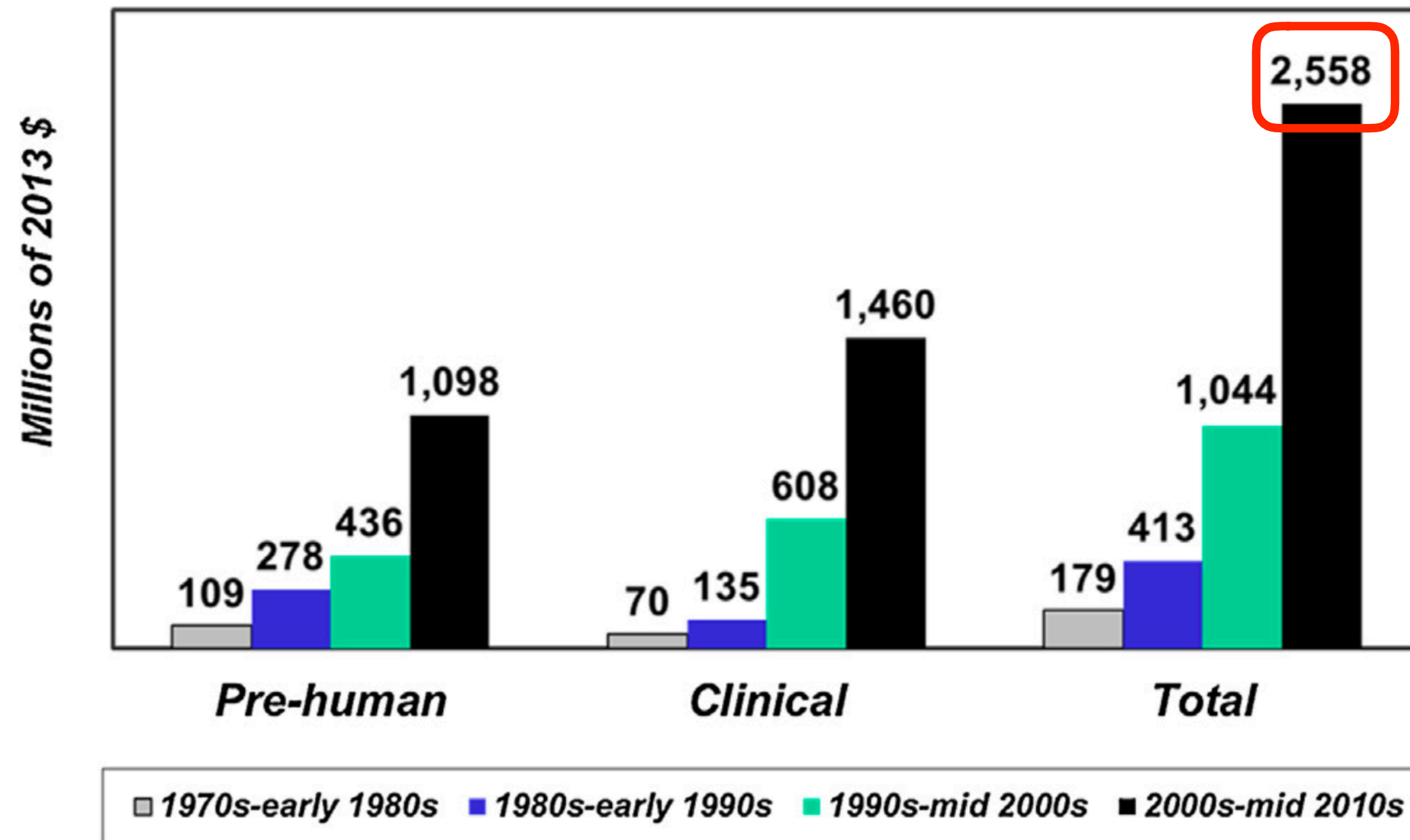
J.A. DiMasi et al. / Journal of Health Economics 47 (2016) 20–33 21
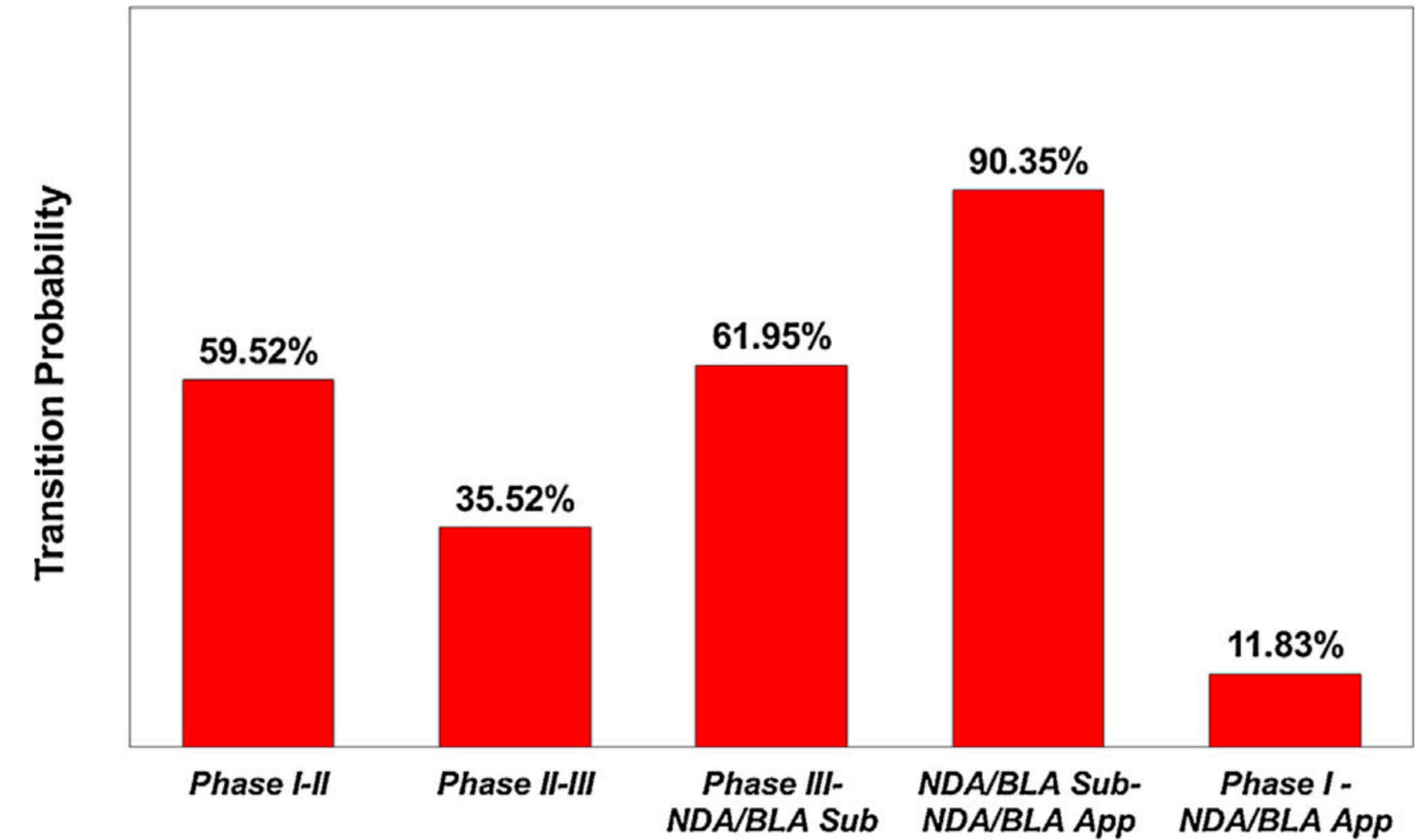
NDA/BLA Sub = New Drug Application/Biologic License Application submission
NDA/BLA App = New Drug Application/Biologic License Application approval

$2.5 billion to develop a new drug
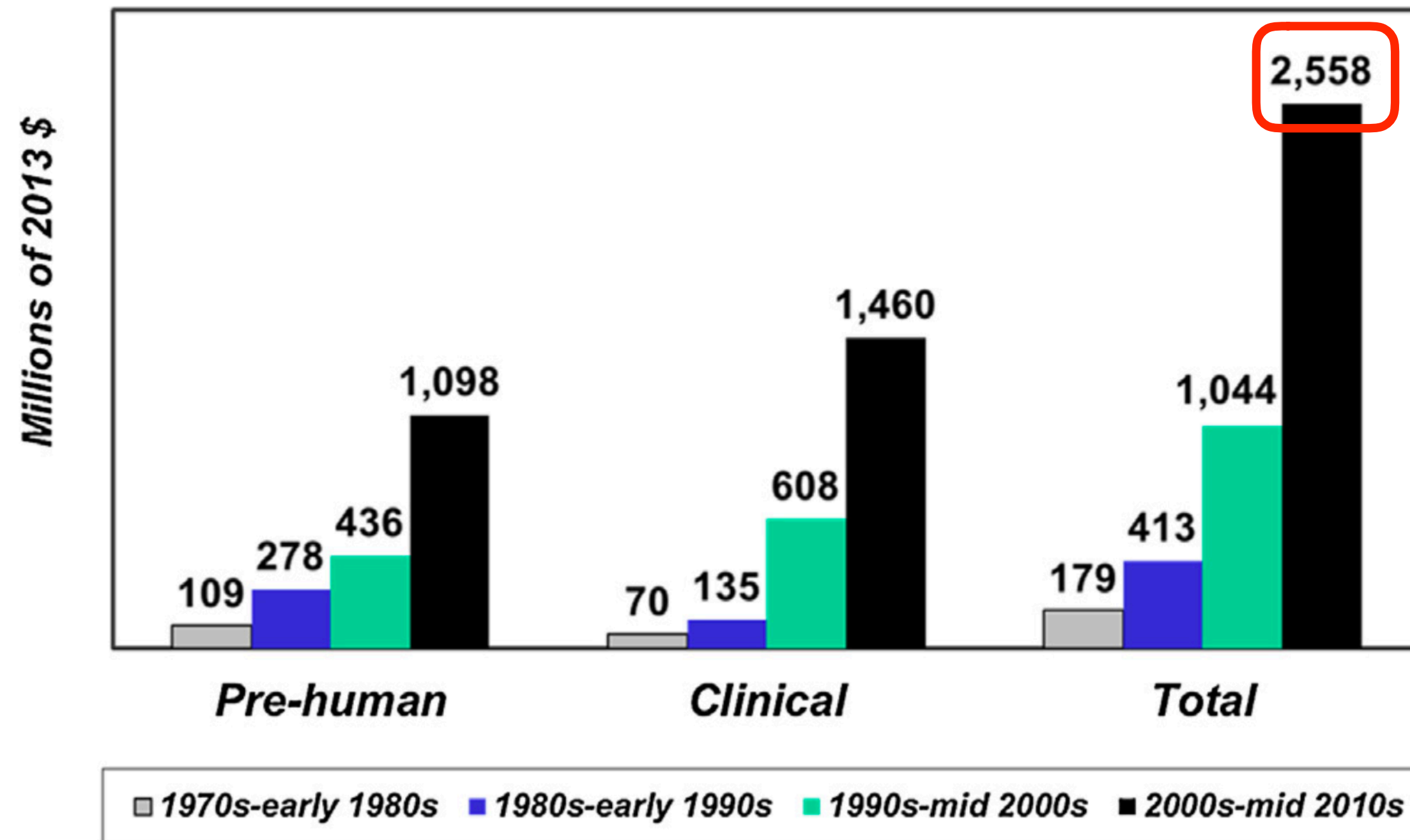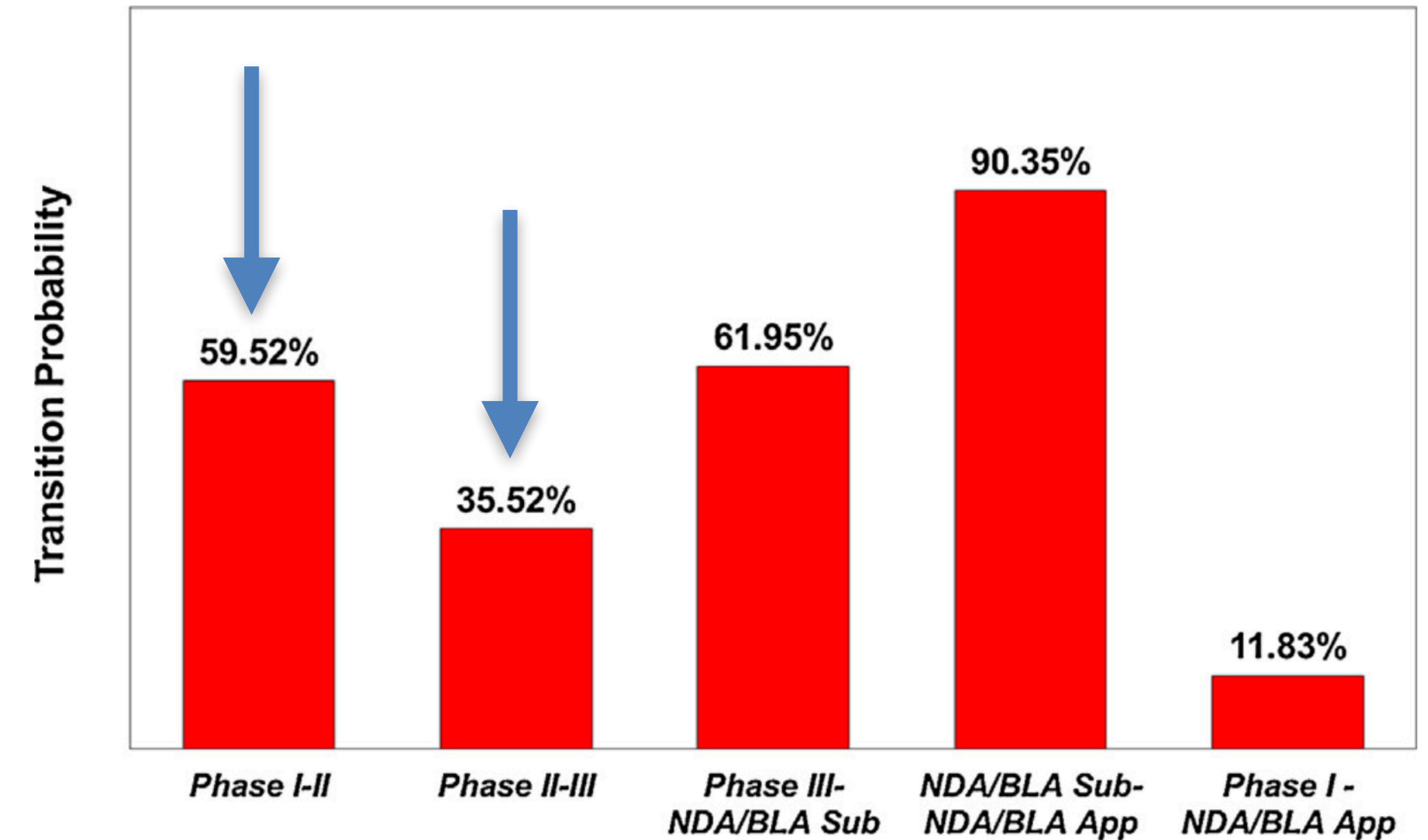
J.A. DiMasi et al. / Journal of Health Economics 47 (2016) 20–33 21

NDA/BLA Sub = New Drug Application/Biologic License Application submission
NDA/BLA App = New Drug Application/Biologic License Application approval

Bad data lead to waste.

There is a better way.

The quantified self movement

I ♥ ME

18 ways to spot a narcissist
Amanda Chan
Huffpost, February, 2014

@samvolchenboum

LITMUS | HEALTH

Wearables are ubiquitous

http://medicalfuturist.com/

@samvolchenboum

LITMUS | HEALTH

mHealth is everywhere

- ~250K mHealth apps

- >120M wearables by shipped in 2019

- 6 billion smartphones by 2020

- Clinical grade wearables market to reach $19B by 2020

http://bit.ly/2fgzB2J

THE UNIVERSITY OF
CHICAGO MEDICINE &
BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

The challenge

There are barriers to mHealth

FDA News Release

FDA approves pill with sensor that digitally tracks if patients have ingested their medication

The New York Times

First Digital Pill Approved to Worries About Biomedical 'Big Brother'

By **PAM BELLUCK**   NOV. 13, 2017

Some worry that the devices aren't accurate

The New York Times

Just How Accurate Are Fitbits? The Jury Is Out

By MIKE McPHATE   MAY 25, 2016

CRUNCH NETWORK

What the Fitbit lawsuit means for clinical researchers

Posted Aug 18, 2016 by Daphne Kis, Dr. Samuel Volchenboum August, 2016

@samvolchenboum

The popular press isn't helping…

Here's what happened when I wore 10 fitness trackers at once

Eric Chemi
Published 12:59 PM ET Thu, 26 May 2016 | Updated 4:03 PM ET Tue, 7 June 2016

CNBC

Going the distance

In CNBC's unscientific test, we saw significant variance in our two days of testing.

	Test 1 = 2 hours	Test 2 = 0.5 miles
Apple Watch (1)	0.52	0.46
Apple Watch (2)	1.12	0.47
Fitbit Charge HR	0.98	0.44
Fitbit Flex	0.91	0.41
Garmin vívosmart HR	1.04	0.48
Jawbone UP3	1.1	0.48
Misfit Flash	0.7	0.3
Polar A360	0.7	0.4
Withings Pulse O_2	0.51	0.51

Source: Big Crunch research. Note: Not a scientific study.

CNBC

https://goo.gl/DTKqfS

@samvolchenboum

LITMUS | HEALTH

The scientific literature is a little better…

JAMA
The Journal of the American Medical Association

Accuracy of Smartphone Applications and Wearable Devices for Tracking Physical Activity Data

Meredith A. Case, BA; Holland A. Burwick; Kevin G. Volpp, MD, PhD
Perelman School of Medicine, University of Pennsylvania, Philadelphia
Amherst College, Amherst, Massachusetts
Center for Health Equity Research and Promotion, Philadelphia VA Medical Center, Philadelphia, Pennsylvania

Figure 2. Device Outcomes for the 1500 Step Trials

Device	No. of Observations
Galaxy S4 Moves App	28
iPhone 5s Moves App	28
iPhone 5s Health Mate App	27
iPhone 5s Fitbit App	27
Nike Fuelband	28
Jawbone UP24	28
Fitbit Flex	28
Fitbit One	26
Fitbit Zip	27
Digi-Walker SW-200	28

Mean No. of Steps: 500 1000 1500 2000

@samvolchenboum

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

LITMUS | HEALTH
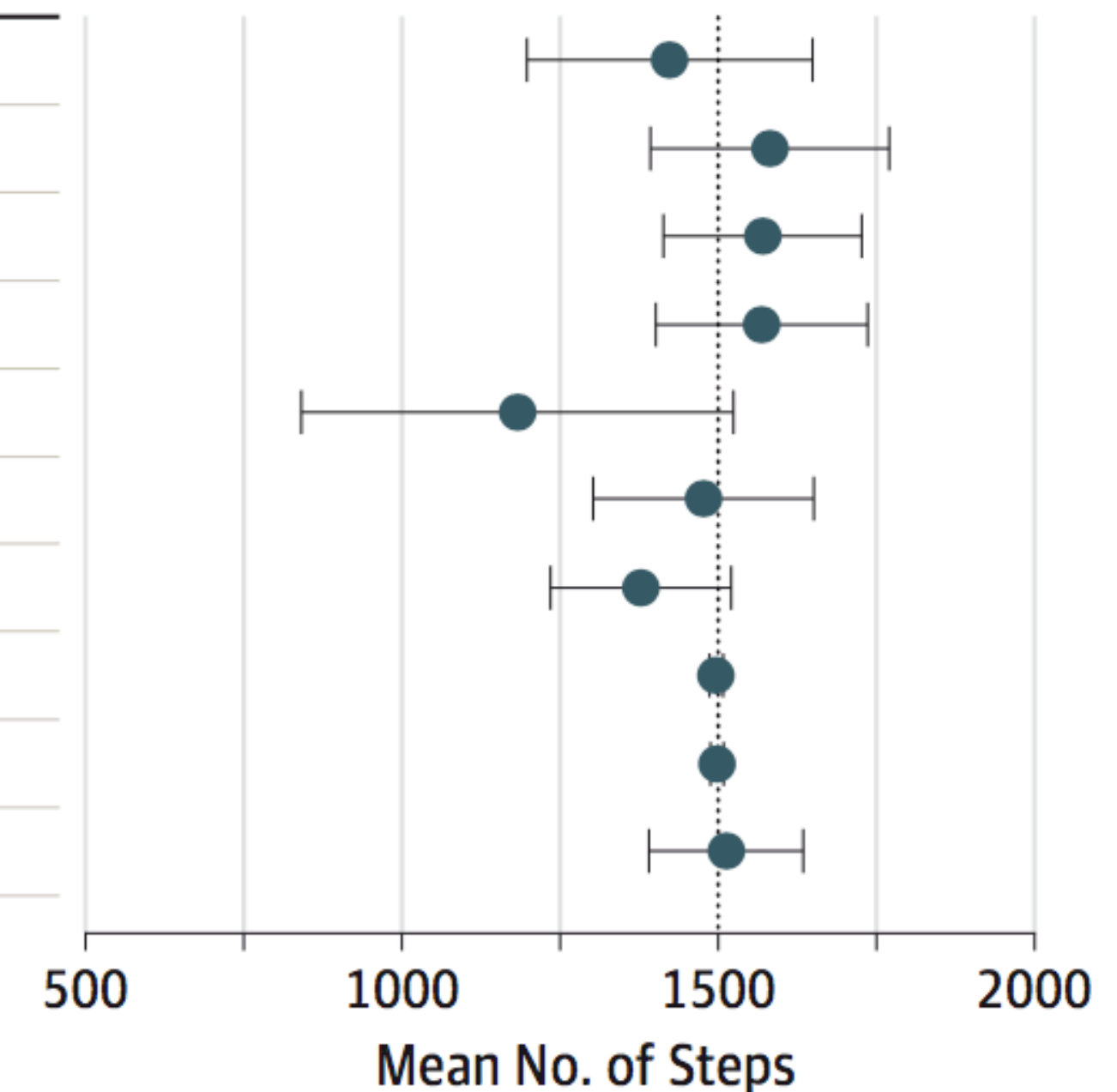
BYOD is taking over the field

"Bring your own device" allows participants in a trial to use their own wearable, phone, or tablet
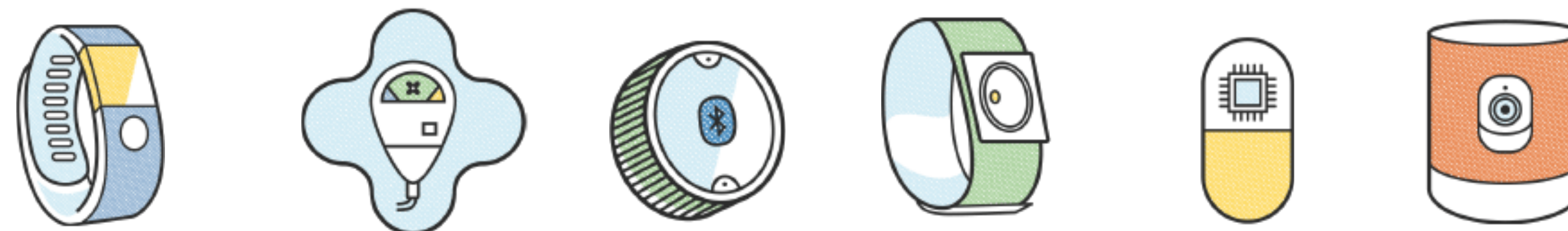
BYOD is good for trials

- Reduced cost

- Increases compliance

- Minimize visits to clinic / patients stay at home

The use of digital technologies to collect patient data in outcomes research
Bill Byrom and Bill Rom, ICON Clinical Research
Journal of Comparative Effectiveness Research, June 2017
https://www.ncbi.nlm.nih.gov/pubmed/28621550

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

There are concerns about BYOD

- Bias - User has to have their own device

- Data provenance - Device IDs

- Blinding the user to results

- Opaque algorithms

http://www.partylinecentral.com/

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH
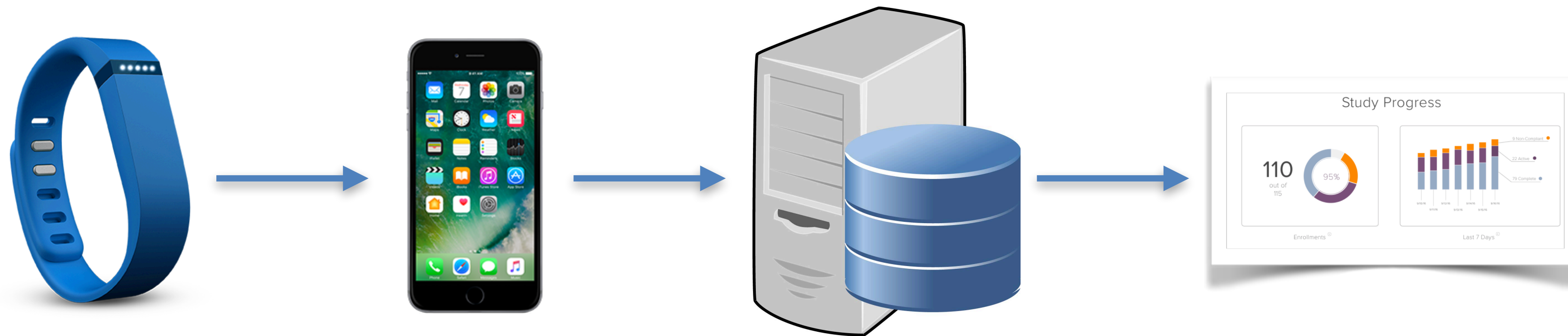
BYOD devices are not secure

We examined fitness trackers…finding that fitness data can be falsified in many cases, and that most fitness wearables emit a trackable unique identifier. *We found that fitness data is often not treated as personal data by companies.*
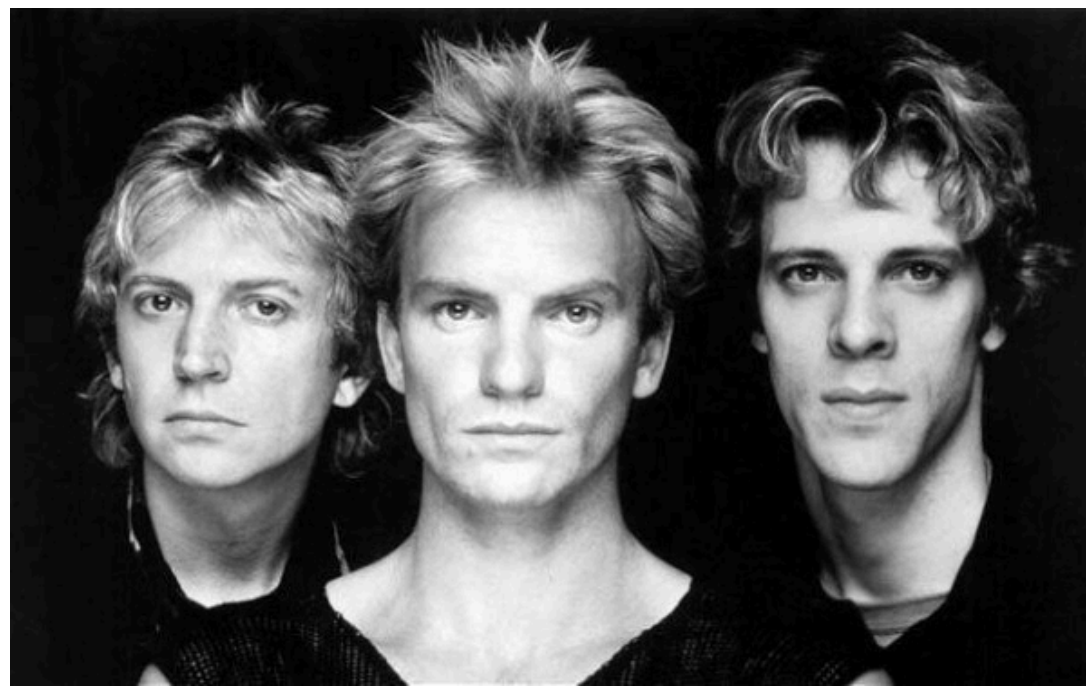
Every Step You Fake
A Comparative Analysis of Fitness Tracker Privacy and Security
Andrew Hilts, Christopher Parsons, and Jeffrey Knockel
Open Effect Report (2016)
https: //openeffect.ca/reports/Every_Step_You_Fake.pdf

@samvolchenboum

LITMUS | HEALTH

But what about the FDA?

@samvolchenboum

The FDA is bullish on wearables

- No formal guidance… yet ("Risk-based approach")

- "Cautious optimism" that devices would provide better and more timely insight into a patient's health status

- Consumer-grade devices can be used as long as they are "fit for purpose"

- Announced new Digital Health Innovation Plan

Wearables Shaping The Future Of Clinical Trials
Keith Wenzel, Clinical Informatics News, April, 2017
http://bit.ly/2rBqZEw

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS   @samvolchenboum   LITMUS | HEALTH

Wearables are transforming clinical trials

The use of wearable technology in clinical trials has the potential to be *one of the most disruptive innovations in drug development*.

Remote Monitoring of Patients in Clinical Trials
Marie McCarthy, Michael Philips, Bill Byrom, Willie Muehlhausen
Allied Clinical Trials, Sep 12, 2016

THE UNIVERSITY OF
CHICAGO MEDICINE &
BIOLOGICAL SCIENCES

CENTER FOR
RESEARCH
INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Wearables will make clinical trials **better**, **faster**, and **cheaper**.

Wearable data are more reliable

- Subjects under-report activities

- Data are better quality

- More transparent audit trail

- Reduced patient burden

- Increased patient engagement

Examining the potential impact of wearables in the healthcare space
Andrena Logue, Kable, May, 2016, ClinicalTrialsArena
https://goo.gl/NLfkNw

Remote Monitoring of Patients in Clinical Trials
Marie McCarthy, Michael Philips, Bill Byrom, Willie Muehlhausen
Allied Clinical Trials, Sep 12, 2016

**Understanding physical activity in cancer patients and survivors:
new methodology, new challenges, and new opportunities**
Cold Spring Harb Mol Case Stud. 2017 Jul; 3(4): a001933. PMCID: PMC5495035
Jennifer A. Schrack, Gillian Gresham, and Amal A. Wanigatunga

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

A new way to collect sleep data
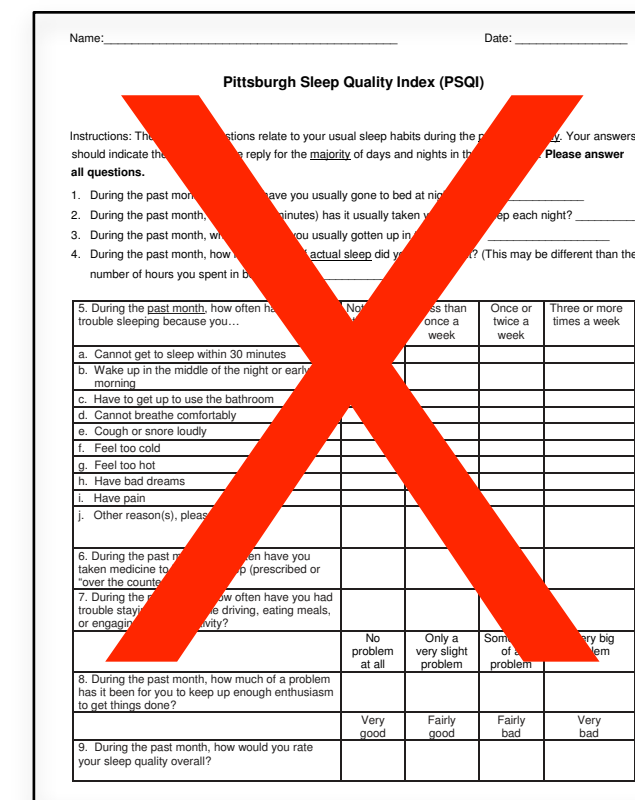
Doctor conducts research study

>

Sleep is recorded passively

>

Data reflect what actually happened to the patient

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Wearables are transforming COA

mHealth data type	Clinical outcomes assessments (COAs)			non-COA
	Patient/caregiver-reported outcome (*PRO*)	Clinician-reported outcome (*ClinRO*) (requires HCP)	Performance outcome (*PerfO*) (requires HCP)	Biomarker or surrogate endpoint
Patient/caregiver-reported data	**Mobile device questionnaire**	**Photo uploaded by patient**		
Task-based measures	**PRO support? (e.g., med adherence)**		**Six minute walk test?**	**Smartphone memory test**
Active sensor data	**PRO support? HR + feeling faint**		**Smart-phone based spirometer?**	**Home blood glucose**
Passive sensor data	**PRO confirmation? PSQI + sleep**		**Data mining to document fitness?**	**HR, steps, sleep**

Volchenboum SL, Lane A, Cox SC; "*Use of wearable, mobile, and sensor technology in cancer clinical trials*" JCO Clin Informatics, *in press.*

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Changes to eCOA are coming

Selection of and Evidentiary Considerations for Wearable Devices and Their Measurements for Use in Regulatory Decision Making: Recommendations from the ePRO Consortium

Bill Byrom, PhD[1],*, Chris Watson, PhD[2], Helen Doll, DPhil[3], Stephen Joel Coons, PhD[4], Sonya Eremenco, MA[4], Rachel Ballinger, PhD[3], Marie Mc Carthy, MBA[5], Mabel Crescioni, DrPh[4], Paul O'Donohoe, MSc[6], Cindy Howry, MS[7], on behalf of the ePRO Consortium

[1]ICON Clinical Research, Marlow, Buckinghamshire, UK; [2]ERT, Nottingham, Nottinghamshire, UK; [3]ICON Clinical Research, Abingdon, Oxfordshire, UK; [4]Critical Path Institute, Tucson, AZ, USA; [5]ICON Clinical Research, Dublin, Ireland; [6]CRF Health, London, UK; [7]assisTek, Scottsdale, AZ, USA

https://www.journals.elsevier.com/value-in-health, 2017

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Wearables can help shift care from clinic to home

- Choosing the right sensors

- Defining the endpoints

- Addressing all privacy and security concerns

- Data integration into traditional workflows

Remote Monitoring of Patients in Clinical Trials
Marie McCarthy, Michael Philips, Bill Byrom, Willie Muehlhausen
Allied Clinical Trials, Sep 12, 2016

Standardization is essential

- Standards for interoperability (Open mHealth, CDISC, ISO)

- What defines valid data? Missing data?

- How do we define summary statistics?

- New measures of QoL?

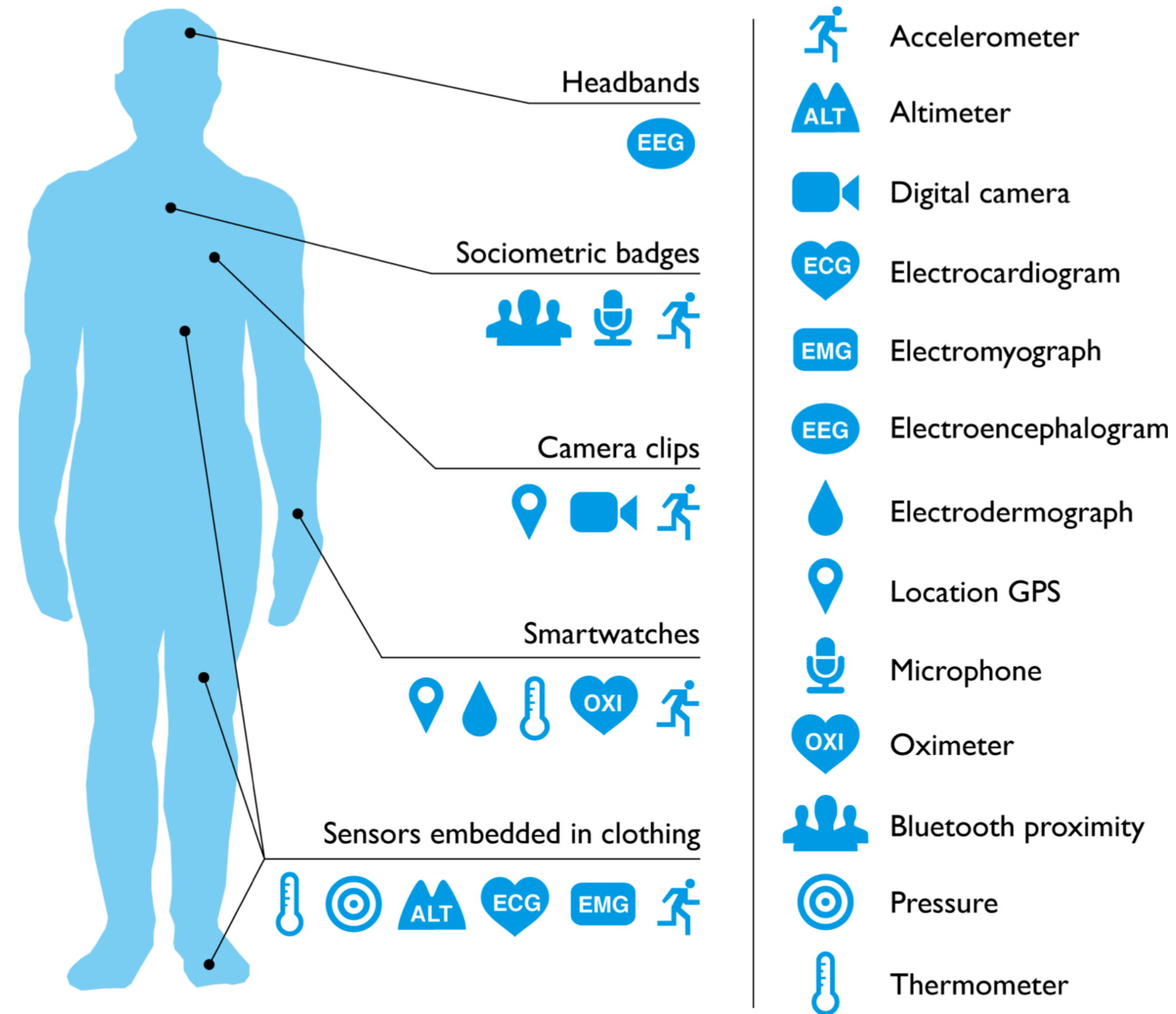**Wearables in Clinical Trials: An Active Interest?**
Bill Byrom, Applied Clinical Trials
Jul 29, 2014 http://www.appliedclinicaltrialsonline.com/print/245084

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Quality of life is the ultimate endpoint

Imagine when the whole world becomes a clinical trial

The Rise of Consumer Health Wearables: Promises and Barriers.
Piwek L, Ellis DA, Andrews S, Joinson A
PLoS Med 13(2): e1001953. pmed.1001953, Feb 2016

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Living longer and better lives

Living longer and better lives

Living longer and better lives

https://www.stayyounghealthy.com/meet-hero-still-running-age-105-fauja-singh/

THE UNIVERSITY OF CHICAGO MEDICINE & BIOLOGICAL SCIENCES | CENTER FOR RESEARCH INFORMATICS

@samvolchenboum

LITMUS | HEALTH

Bringing it all together

- Wearables, sensors, and smartphones are transforming the clinical trials industry

- Concerns are valid but surmountable

- Keys to success are standardized data collection and normalization with appropriate attention to privacy and security

@samvolchenboum

LITMUS | HEALTH