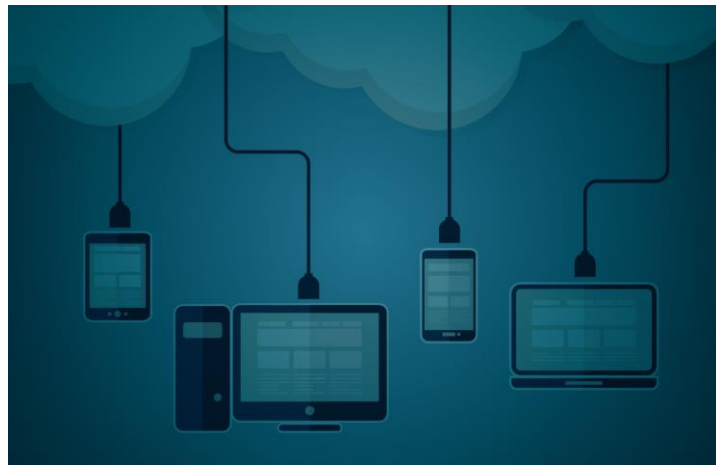


Improving Outcomes and Efficiency in CV Medicine: The Role of Big Data, AI and Remote Monitoring



Kevin R. Campbell, MD, FACC
CEO, PaceMate™



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DISCLOSURES

- CEO, PaceMate™
- Medical Advisory Board, AliveCor, Inc.
- Contributor, Fox News, CNN, MSNBC, CBS
- Contributor, U.S. News & World Report



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TODAY'S HEALTHCARE IS ALL ABOUT BIG DATA

>500
PETABYTE

There is an estimated 500
petabytes of data in the
healthcare realm

1024 Kilobytes = 1 Megabyte
1024 Megabytes = 1 Gigabyte
1024 Gigabytes = 1 Terabyte
1024 Terabytes = 1 Petabyte
1024 Petabytes = 1 Exabyte

KAISER PERMANENTE HAS MORE THAN 47 PB OF DATA IN THEIR EHR ALONE!



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IMPORTANT ATTRIBUTES OF BIG DATA IN MEDICINE: THE 3 V'S



VELOCITY

Real-time Biometric data flows faster than a heart beats



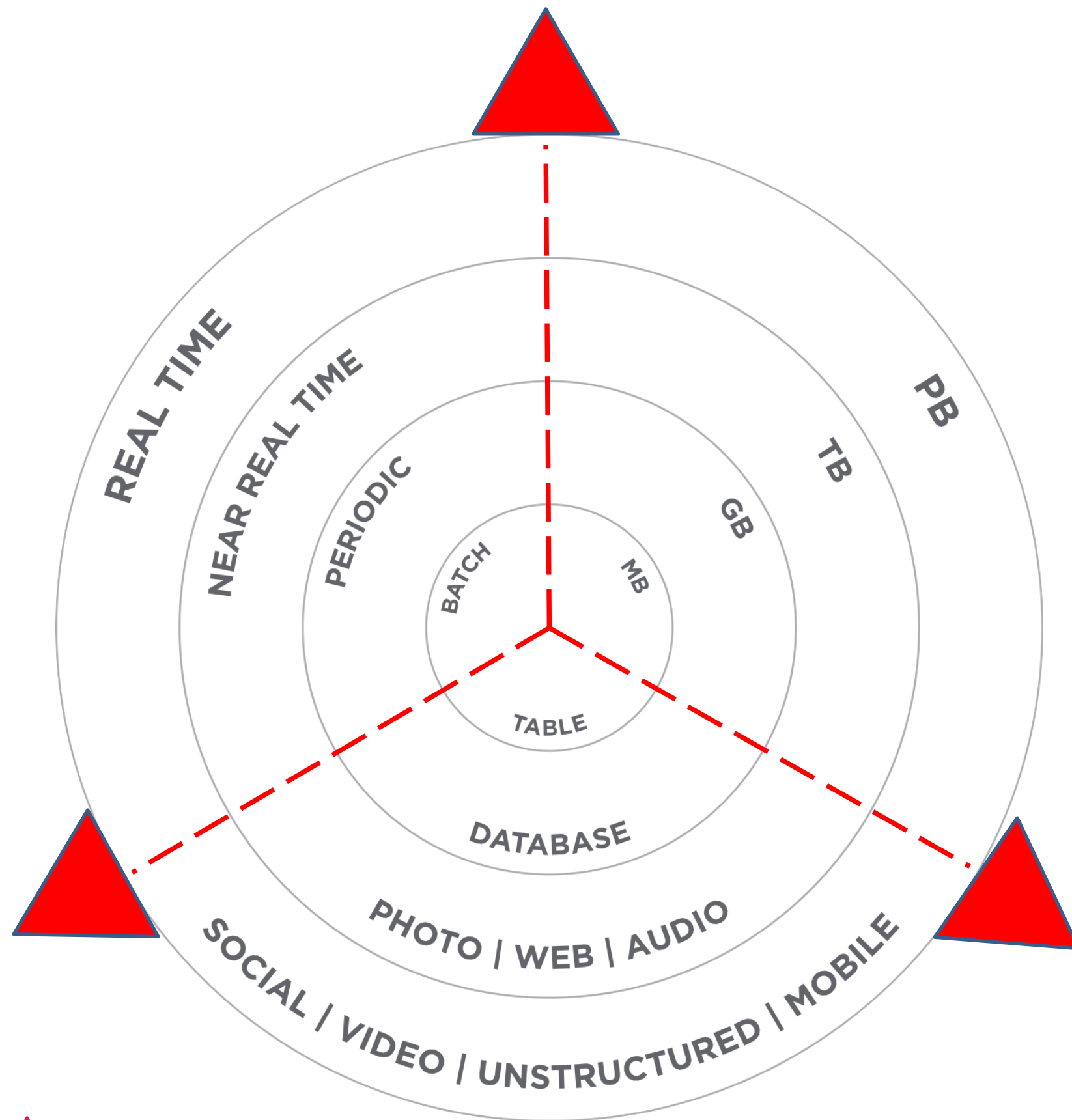
VARIETY

Lots of ways to measure biometrics



VOLUME Device data is generated 24-7 and NEVER stops

"3D Data Management: Controlling Data Volume, Velocity and Variety," Doug Laney, 2001



BIG DATA:
EXPANDING ON
ALL 3 FRONTS AT
AN INCREASING
RATE



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SHOULDN'T WE ADD VIABILITY AND VALUE?

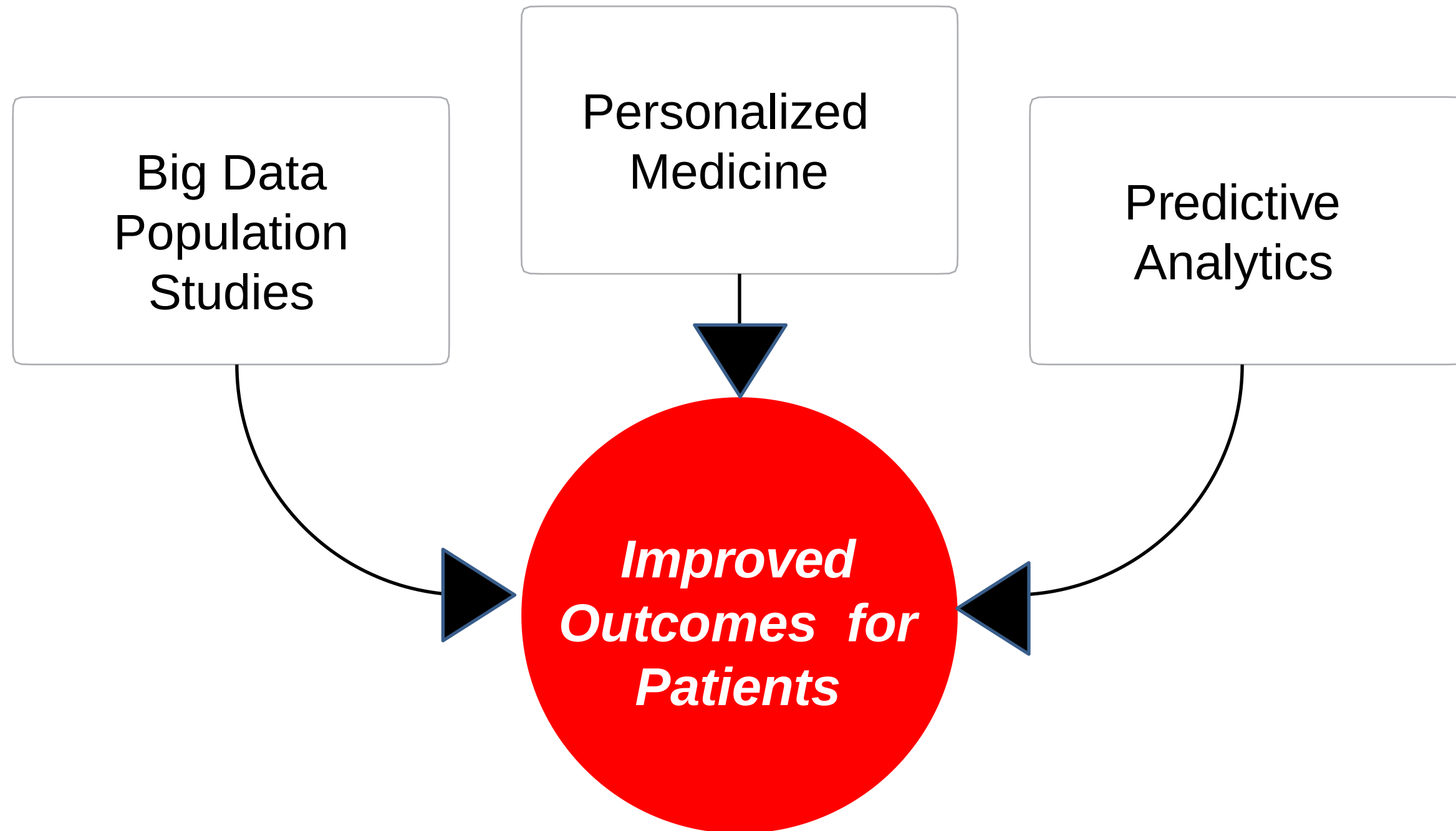
Viability of Data—With so many varieties of data and variables to consider in building an effective predictive model, we **MUST** quickly and cost-effectively test and confirm a particular variable's relevance before investing in the creation of a fully featured model

Value of Data—We **MUST** create a model that answers sophisticated queries, delivers counterintuitive insights, and creates unique learning. These needle-moving actions and behaviors start to tap into the fifth V from Big Data: value.



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THE DICHOTOMY OF BIG DATA



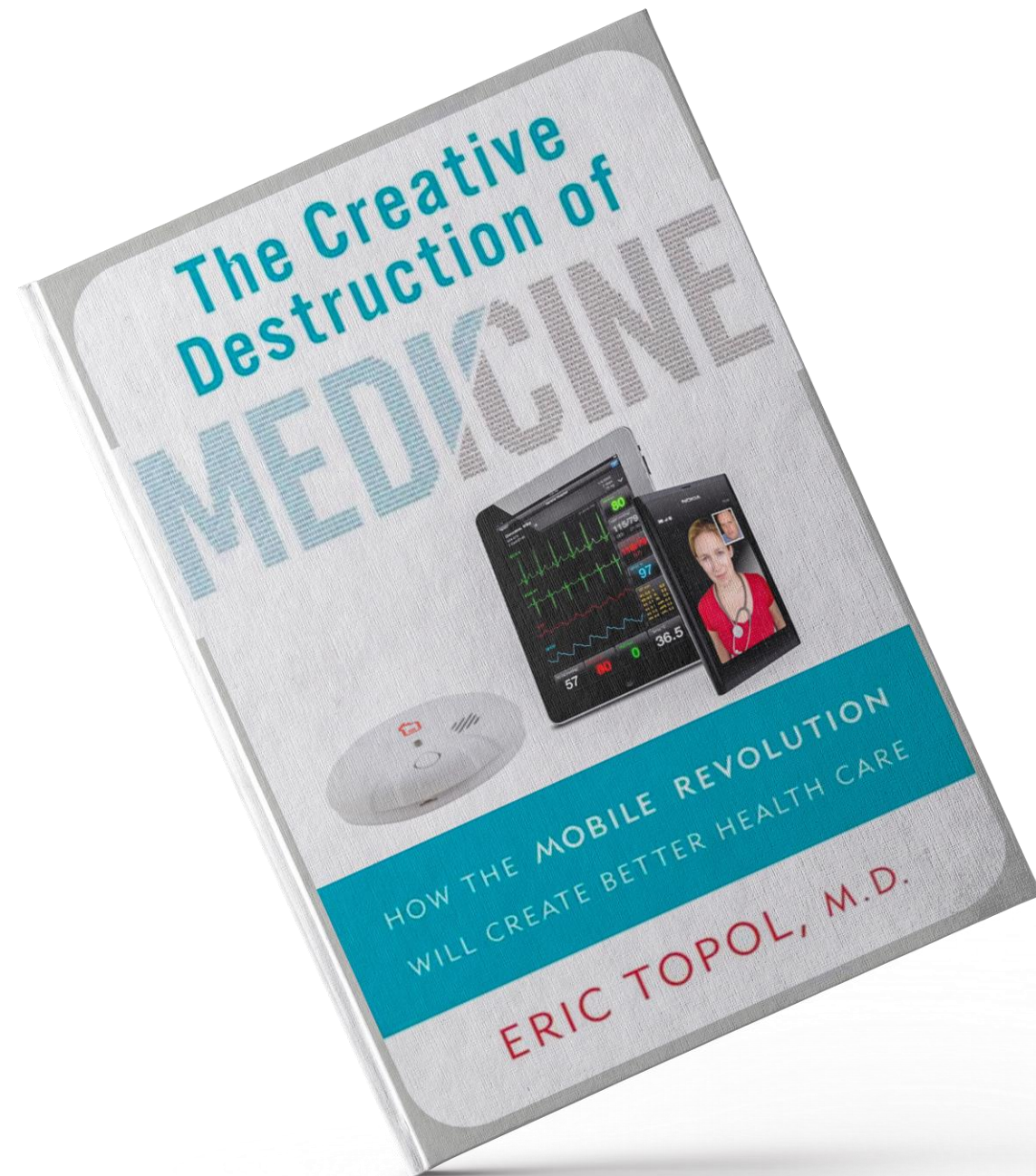
WHAT WE ARE REALLY TALKING ABOUT IS PERSONALIZED MEDICINE

PERSONLIZED MEDICINE IS MADE POSSIBLE
THRU SMART USE OF BIG DATA...

- Innovation that enables real-time diagnosis and individualized treatments is a certainty and a game changer.
- Using DATA to determine the course of disease—
More importantly, HOW WE USE THE DATA CAN
ALTER THE COURSE OF THAT DISEASE



THE WAY WE PRACTICE MEDICINE IS CHANGING



INFORMATION ERA CONVERGING WITH DIGITAL ERA

"A new model of medicine is being induced by the digital era and the altered way in which information will be flowing" –Eric Topol, MD



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HOW CAN WE USE DIGITAL TOOLS TO IMPROVE CARE?



“The digital world has been in a separate orbit from our medical cocoon, and it's time the boundaries be taken down. The problem is that it takes physicians so long to accept a radical change... And the lag is unacceptable.”

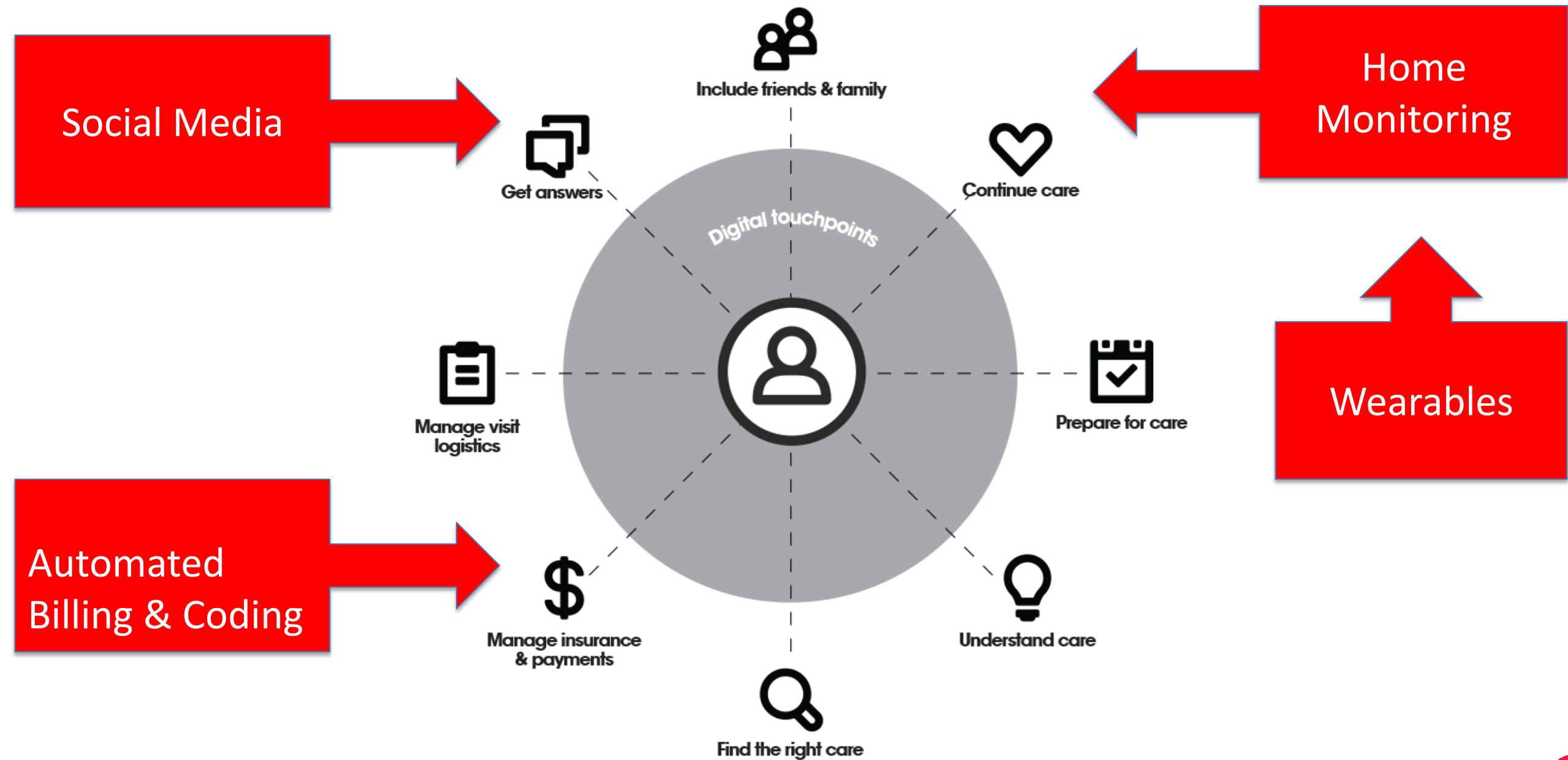
—Eric Topol, MD



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Digital Space Can Improve Access and Outcomes for Patients (and Help Docs)

Digital touchpoints can create an improved patient ecosystem:



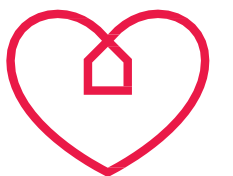
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Applications of Big Data and AI in Medicine

- Predict epidemics
- Cure disease
- Improve quality of life
- Avoid preventable deaths



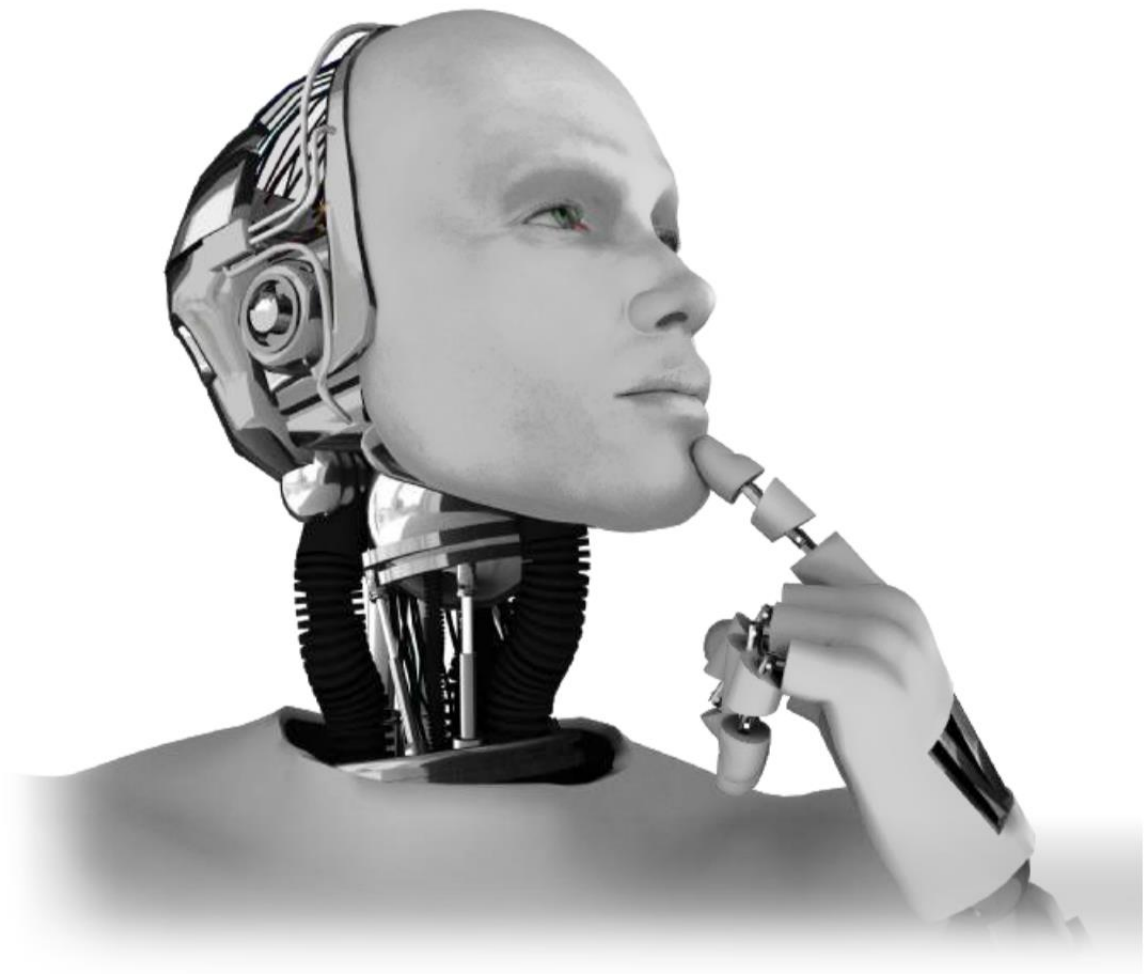
"Prevention is far better than Cure" and BIG data promotes PREVENTION and PREDICTION



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WHAT IS ARTIFICIAL INTELLIGENCE (AI)?

- Using Computers to Solve Problems or Make automated decisions for tasks that when performed by humans require intelligence
- TWO major approaches
 - Logic and Rules Based
 - Pattern Based



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AI, Machine Learning and Deep Learning...



EP PERSPECTIVES

Disruptive Technologies: How Artificial Intelligence Will Transform Healthcare and Electrophysiology

Volume 18 - Issue 5 - May 2018

Kevin R. Campbell, MD, FACC

CEO, PaceMate, Inc



PaceMate™

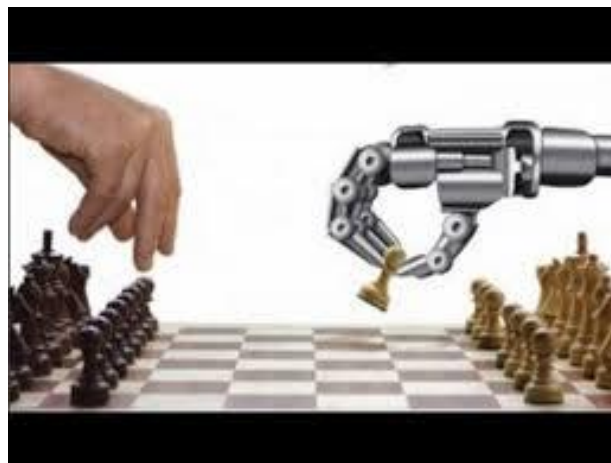
Unstacking the Dolls....

- AI—The Simulation of Human intelligence by Computer Systems
- Machine Learning--using algorithms to analyze data, learn from it, and then make determinations, decisions, and predictions. In essence, machine learning is the ability for computers to “learn” without being specifically programmed to do so through complex pattern recognition.



Unstacking the Dolls....

- Deep Learning--Deep learning relies on two concepts — deep artificial neural networks and deep reinforcement learning
 - *Neural networks are a set of algorithms designed to recognize patterns in an effort to cluster and classify data.*
 - *Reinforcement learning centers around more goal-oriented algorithms. These algorithms are actually able to learn how to attain a complex objective (goal)*



TRANSLATING DIGITAL TOOLS INTO RESULTS FOR PATIENTS

- ***Remote Monitoring/Connectedness***
 - Patient Engagement, Improved Outcomes, Cost Savings, Improved Compliance
 - DATA gathered from the “Connected Patient” not only impacts the care of that patient but can be used to help entire populations

Applications of AI in Medicine....

- Personalized Medicine
- Disease Identification
- *Disease Management/Remote Monitoring*
- Therapy Development/Clinical Trials



MONITORING.....

“is the essence of digitizing a human being. For medical purposes, it's getting all the essential data, and it will be the information to radically transform the future of medicine.”

—Dr. Eric Topol

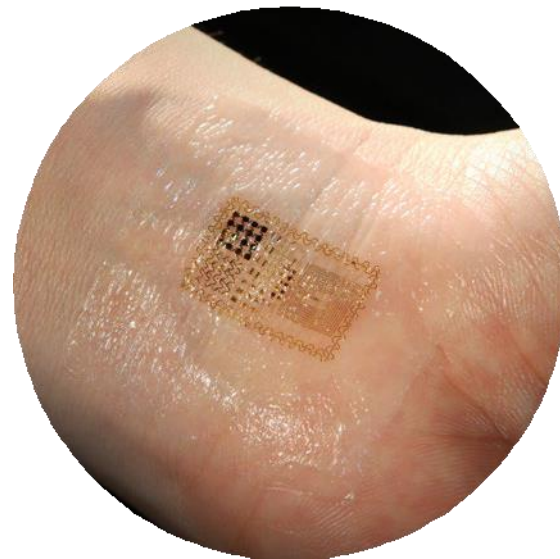


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EXAMPLES OF MONITORING TECH IN 2018



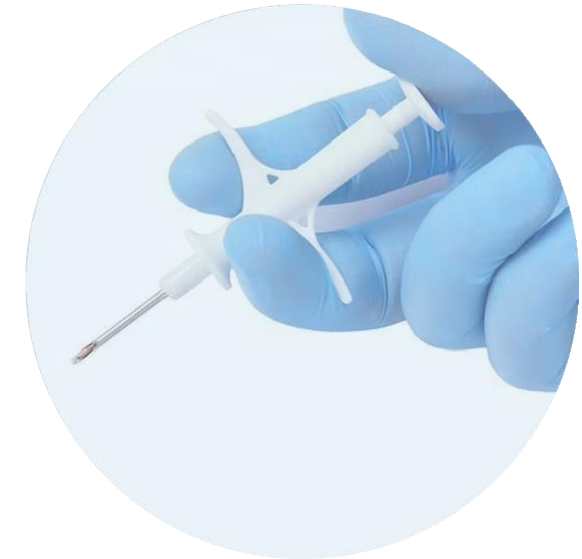
Wearables



Smart Tattoos



Dermally
Implanted
Sensors



Subcutaneous
Implants



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HOME MONITORING HAS REVOLUTIONIZED CARDIAC CARE

- We now have the ability to care for our patients and base decision making on **REAL-TIME DATA** from at-home devices
- Robust research supports the empowerment of both doctor and patient through the use of **REMOTE MONITORING DEVICES**

REMOTE MONITORING WORKS—BETTER OUTCOMES

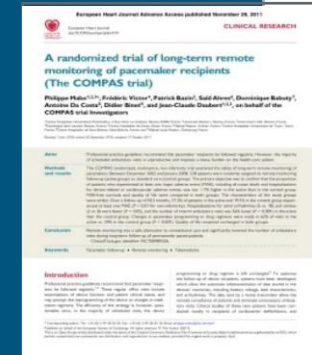
Trust Study

Home monitoring reduces in-office follow-up burden and provides earlier detection of arrhythmias



Compas Study

Home monitoring reduces hospitalizations for atrial arrhythmia and related strokes as well as interim office follow-ups



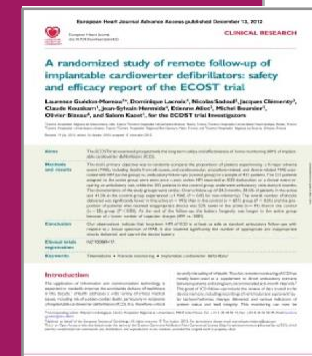
In-Time Study

Home monitoring significantly increases survival



ECOST Study

Home monitoring significantly reduces inappropriate shocks and extends battery longevity



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REMOTE HOME MONITORING IS THE NEW STANDARD OF CARE FOR CARDIAC DEVICES

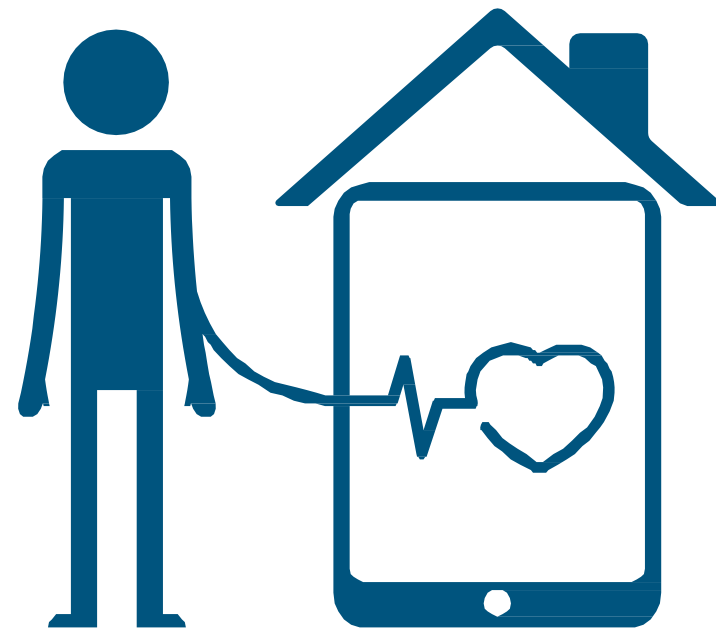
“A strategy of remote CIED monitoring and interrogation, combined with at least annual IE, is recommended over a calendar-based schedule of in-person CIED evaluation alone (when technically feasible).”

—Heart Rhythm Society Remote Monitoring
Consensus Statement Recommendations, 2015



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THE NUMBER OF “CONNECTED” PATIENTS IS GROWING

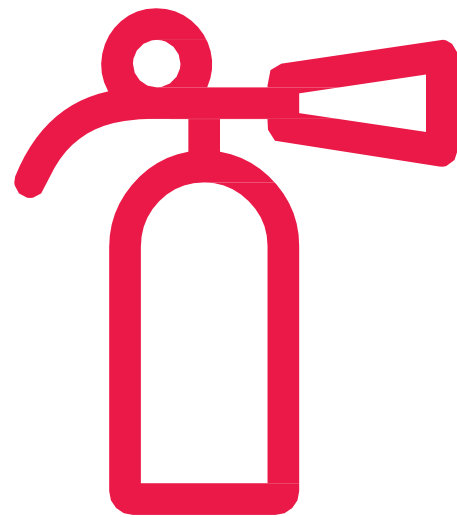


The total number of patients worldwide using connected home medical monitoring devices is expected to soar to **19.1 MILLION** over the next **3.5 YEARS**



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WE NEED DATA MANAGEMENT SOLUTIONS NOW



Think of the data currently generated from
medical devices as a
HOUSE ON FIRE



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HOW DOES IT WORK?



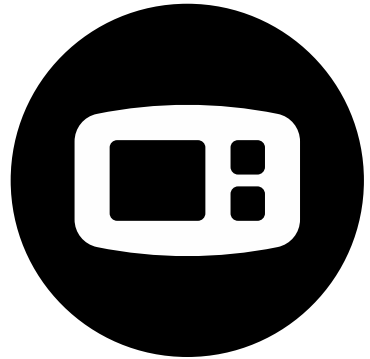
MANAGE | MONITOR | MONETIZE

PaceMate™ LIVE integrates real-time, device-generated data from all major device manufacturers to our cloud for immediate review, reporting and full EHR integration.



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OPEN PLATFORM INTEGRATES WITH ANY MANUFACTURER



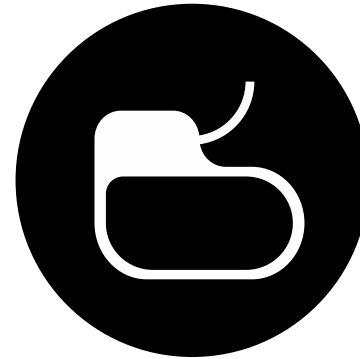
ANY
AMBULATORY
DEVICE



MEDTRONIC



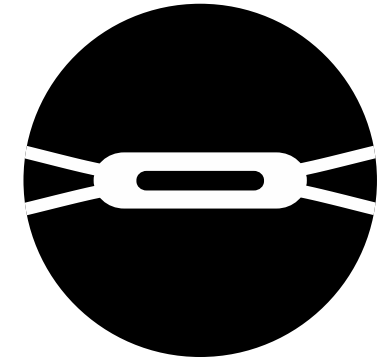
BOSTON
SCIENTIFIC



BIOTRONIK



ST JUDE
ABBOTT



CARDIOMEMS

If you can place a monitoring device IN a patient, NEAR a patient or ON a patient, PaceMate™ can manage and process the data



PaceMate™



PaceMate™
powered by biocynetic™

Transmission for Approval ☐ Billable Only

SEARCH

☒	Clinic	Last Name	First Name	Date of Birth	Transmission Date	Manufacturer	Device Model	Device Type	Transmission Type	Report Type	Details
☒	DH	Chan	Bob	3/27/1964	7/5/2018 0:0	MDT	LNQ11	Monitor	Remote	Full Report	View
☒	DH	Dean	Dean	12/11/1928	7/17/2018 0:0	MDT	LADDR1	IPG	Remote		View
☒	UH	King	Jill	1/28/1946	7/20/2018 0:0	STJ	3265-40Q Quadra Assura(TM)	CRT_D	Remote		View
☒	DH	Lopez	Cara	3/23/1941	4/2/2018 0:0	BSX	V173	CRT_P	Remote		View
☒	DH	Hand	Phil	8/13/1952	6/10/2018 0:0	BTK	Advise DR MRI A2DR01	IPG	Remote		View
☒	DH	Henry	Don	7/12/1939	6/12/2018 0:0	BSX	N119	CRT_D	Remote		View
☒	CM	Dunn	Matt	1/27/1947	6/18/2018 0:0	MDT	LNQ11	Monitor	Remote	Full Report	View
☒	CM	Pat	Brian	4/11/1952	6/20/2018 0:0	BSX	A219	S_ICD	Remote		View
☒	CM	Carroll	Finn	12/26/1946	6/21/2018 0:0	MDT	LNQ11	Monitor	Remote	Full Report	View
☒	DH	Lane	Mark	10/27/1949	6/21/2018 0:0	MDT	LNQ11	Monitor	Remote	Full Report	View

Export

Approve Selected

Showing 1 to 10 of 1,285 entries

PREVIOUS 1 2 3 4 5 ... 129 NEXT

ORGANIZED, COLOR-CODED ALERTS:

Actionable alerts
always at the top of
your dashboard
and sorted by
clinical relevance.

MASS APPROVAL:

Ability to instantly
approve multiple
reports at a time
with one click.



Provider Dashboard

Transmissions for Approval 1285					
Billable Only					
Name	Clinic	Transmitted	Vendor	Device Type	Type
	DH	07/05/2018	Medtronic	Monitor	Remote
	DH	07/17/2018	Medtronic	IIPG	Remote
	UH	07/20/2018	St. Jude	CRT_D	Remote
	CM	04/02/2018	Boston Sci	CRT_P	Remote
	DH	06/10/2018	Biotronic	IIPG	Remote
	CM	06/12/2018	Boston Sci	CRT_D	Remote

Transmissions for e-Signing 11					
Name	Clinic	Transmitted	Vendor	Device Type	Type
P. Arnold	DH	07/13/2018	Medtronic	Monitor	Remote
Y. Sand	DH	06/06/2018	Medtronic	Monitor	Remote
Q. White	UH	07/03/2018	Medtronic	Monitor	Remote
D. Cook	CM	07/06/2018	Medtronic	Monitor	Remote
K. Hanz	CM	07/08/2018	Medtronic	Monitor	Remote
D. Thomas	DH	07/10/2018	Medtronic	Monitor	Remote

Communications 68							
☒	☒	R. Lee	DH	Medtronic	Monitor	2018/07/17 14:46 EDT	Pt will be away until July 31st and she didn't want to bring her monitor with her
							Boris Shields
☒	☒	O. Reilly	DH	Medtronic	CRT_P	2018/07/17 15:16 EDT	Left VM re: Missed transmission. Gave next 2 transmission dates.
							Claron Burris
☒	☒	V. Holt	UH	Medtronic	JPG	2018/07/16 13:53 EDT	Spoke with patient
							Claron Burris

Clinic Notes 49							
☒	☒	R. Lee	DH	Boston Sci	CRT_D	2018/07/17 11:46 EDT	tachy therapies off due to hx of inappropriate shocks. Scheduled for AV node ablation - at that time therapies will be turned back on.
							Geri Mayer
☒	☒	O. Reilly	DH	Medtronic	CRT_D	2018/07/05 12:06 EDT	Pt requests carelink quarterly vs monthly due to
							Geri Mayer

PATIENT COMMUNICATION: Detailed notes keep everyone in the loop.

E-SIGN: Billing rules engine automatically designates transmissions that require provider's electronic signature.

CLINIC NOTES: Relevant clinical notes are a quick reference on medications and device-specific information.

EVENTS PAGE:

Proprietary billing algorithms are always working in the background for appropriate, timely billing.



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powered by biocynetic™

Review Billing Event

YORK - 07/27/2018

EMAIL SENT

EXCEL

PRINT

SEARCH

Patient Name	Date of Birth	Device Info	CPT Codes	Diagnosis Codes	Device Type	Bill Date	Billing Date	Details	BI/NonBI	Doctor	EMR#
Britton, Ilyas	08/28/1940	Monitor / LNQH1 / RLA4464715	93298, 93299	Device Codes: I63.10 (Cerebral infraction due to embolism of unsp precarb artery)	Monitor	07/26/2018 00:00 EDT	08/25/2018 00:00 EDT	Go To	Billing	Boris Shields	000389
Whittle, Khalid	03/10/1938	Monitor / LNQH1 / RLA4464775	93298, 93299	Device Codes: I63.10 (Cerebral infraction, unspecified)	Monitor	07/25/2018 00:00 EDT	08/24/2018 00:00 EDT	Go To	Billing	Ciaron Burris	000025
Williams, Caitlan	11/17/1949	Monitor / LNQH1 / RLA4464775	93298, 93299	Device Codes: I63.10 (Cerebral infraction due to embolism of unsp precarb artery)	Monitor	07/26/2018 00:00 EDT	08/25/2018 00:00 EDT	Go To	Billing	Boris Shields	000389
Whittle, Khalid	08/31/1993	CRT_P / U138 / 101245	93294, 93296, 93297	Device Codes: I48.1 (Persistent atrial fibrillation)	IPG	07/25/2018 00:00 EDT	08/24/2018 00:00 EDT	Go To	Billing	Boris Shields	000357
Wilkes, Percy	12/02/1934	Monitor / LNQH1 / RLA7168185	93294, 93299	Device Codes: R55 (Syncope and collapse)	Monitor	07/26/2018 00:00 EDT	08/25/2018 00:00 EDT	Go To	Billing	Ciaron Burris	000302
Dawson, Morgan	09/11/1943	IPG / 2240 Assurtyi(TM) DR/ 7714429	93294, 93296	Device Codes: I44.2 (Atrioventricular block, complete)	IPG	07/25/2018 00:00 EDT	10/23/2018 00:00 EDT	Go To	Billing	Ciaron Burris	000341
Velez, Andrew	10/05/1962	Monitor / LNQH1 / RLA9202225	93294, 93299	Device Codes: I63.10 (Cerebral infraction due to embolism of unsp precarb artery)	Monitor	07/25/2018 00:00 EDT	08/24/2018 00:00 EDT	Go To	Billing	Boris Shields	000385

Showing 1 to 7 of 7 entries

PREVIOUS

1

NEXT

FILTER AND SEARCH FROM ANY PAGE:

Ability to filter and search all remote AND in-clinic reports from the same screen.

WHY DOES IT MATTER?



- Live patient data streams are the future of healthcare.
- The biggest shift in digital health over the coming years will be to comprehensive remote monitoring.*

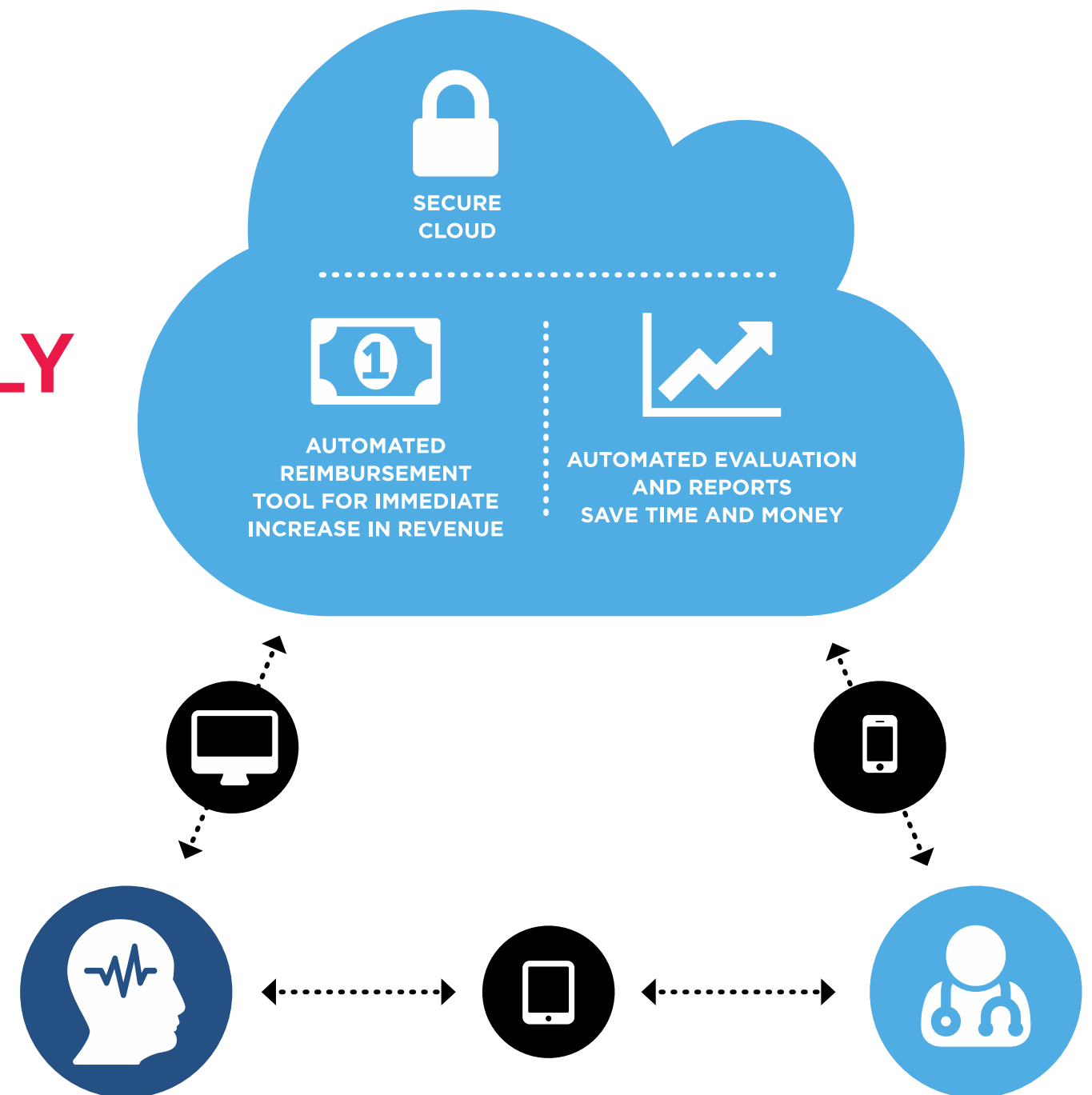
*Survey of 120 senior executives of the top U.S.-based life sciences companies by White & Case LLP



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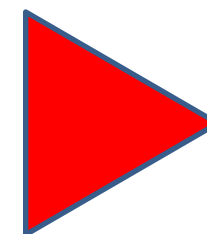
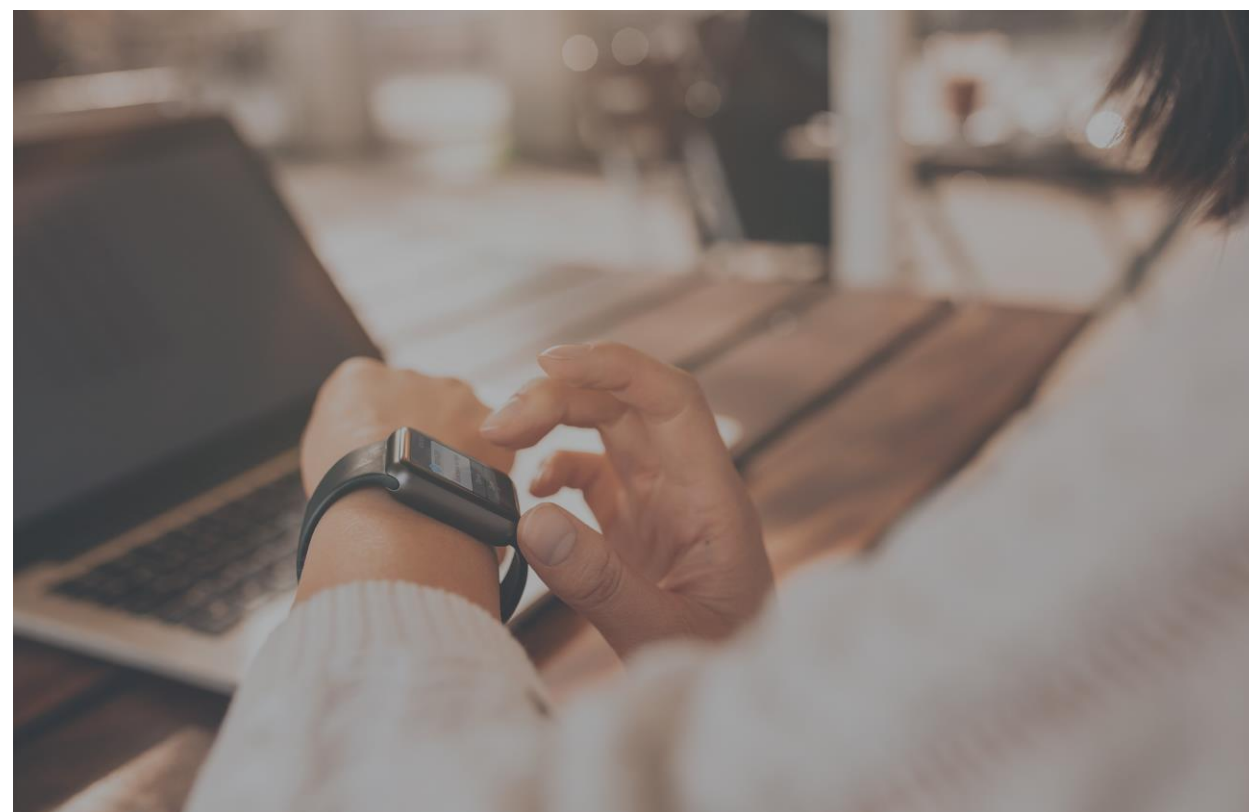
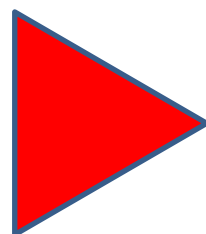
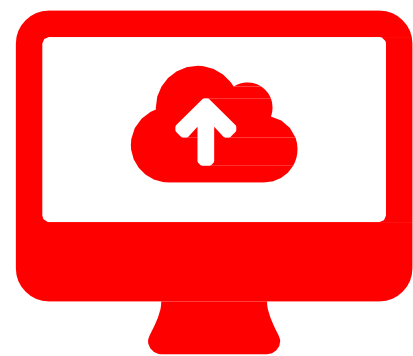
WHAT IS THE PACEMATE DIFFERENCE?

**COLLABORATE WITH TRAINED
SPECIALISTS 24/7/365 SECURELY
FROM ANY DEVICE**

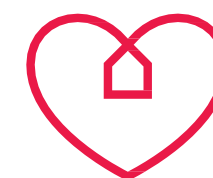


PaceMate™

MAXIMIZING THE UTILITY OF MEDICAL DATA TO SOLVE PROBLEMS



**DIRECT-TO-EHR INTEGRATION
FOR SHARED DATA ON TREATMENTS
AND MEDICATIONS**



PaceMate™



**PACEMATE™ IS SOC-2 CERTIFIED AND
HIPAA COMPLIANT, ENSURING THAT
PATIENT DATA IS SAFE, SECURE, AND
PROTECTED**



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THE PROBLEM



LIABILITY, FAXES, STACKS OF UNREAD TRANSMISSIONS, AND HIGH COST OF PRINTING



CLINICS AND HOSPITALS LOSE MONEY AND WASTE TIME CHASING DEVICE DATA



ENDLESS DATA FROM MULTIPLE SOURCES, IN MULTIPLE FORMATS, ON MULTIPLE PLATFORMS



ALREADY OVERWORKED STAFF

THE RESULT



LOWER THRESHOLD TO IMPLANT SMALLER, SAFER DEVICES = MORE IMPLANTS AND MORE DATA



STACKS OF UNREAD TRANSMISSIONS FROM MILLIONS OF DEVICE PATIENTS



THERE IS NO FULLY AUTOMATED OPTION AVAILABLE TO MONITOR, DOCUMENT, AND COMMUNICATE 24/7/365



THESE THREE THINGS LEAD TO UNTREATED ARRHYTHMIA AND UNNECESSARY STROKES AND DEATH

THE SOLUTION



THE SOLUTION CONTINUED

With better, centralized data, doctors can make better, faster decisions



HAPPIER, HEALTHIER PATIENTS



MAJOR REDUCTION IN UNNECESSARY
HEALTHCARE UTILIZATION REDUCES GOV'T
AND INSURANCE SPEND



PROVEN STRATEGY TO
DECREASE READMISSIONS



LIMIT COST OF CARE FROM
PREVENTION AND
DECREASED UTILIZATION

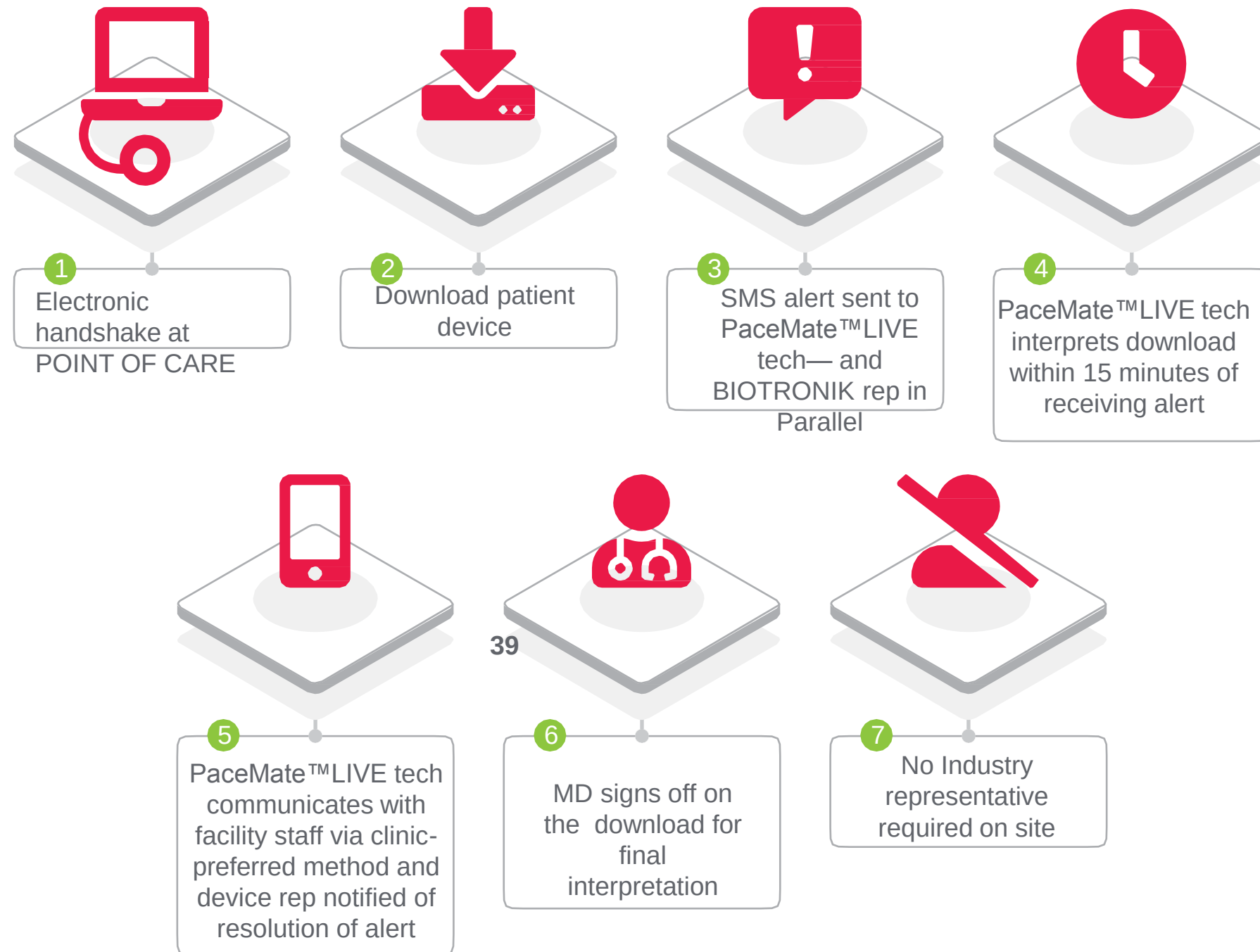


BETTER CLINIC WORK-FLOW
AND IMMEDIATE ROI



DATA USED TO PREDICT AND PREVENT
FUTURE NEGATIVE OUTCOMES

POINT OF CARE SOLUTION WORKFLOW—50,000-FOOT VIEW



PACEMATE™ VALIDATED SUCCESSES



The Utility of Software-Based Remote Monitoring Data Management Systems in CIED Clinics

Kevin R. Campbell, MD, FACC, Noemi Ray, RN, Jason Hale, CCDS

PaceMate™ Bradenton, Florida, USA

Introduction

Remote cardiac monitoring:

- Reduces hospitalizations
- Prevents atrial fibrillation (AF)-related strokes
- Reduce mortality

Data flow never stops and actionable alerts often occur after hours and on weekends

ILR devices generate enormous amounts of data and transmit far more than other device types

- Data can be vital in preventing morbidity/mortality
- False positives also common

Automation of Remote Monitoring is critical to timely data processing and clinical intervention

Purpose

To determine the feasibility of using a software based remote monitoring data management process for improving workflow in a CIED clinic

Methods

- Data obtained from automated remote follow-up of CIEDs utilizing PaceMate™ software technology

- 30 day data capture October/November 2017

- Events classified into GREEN (normal), YELLOW (potential clinical impact) and RED (immediately clinically actionable).

- A comprehensive analysis of the data collected over the study period was then broken down by device type.

Results

- 1441 patients were followed
253 (17%) ICD
682 (47%) PM
182 (12.6%) BIV ICD
37 (2.6%) BIV PM
287 (16.4%) ILR
- 7 RED alerts were generated by either ICDs or BIV ICDs and 6 of 7 were due to VF or VT 1/7 was due to an abnormal lead impedance
- 387 YELLOW alerts and 342 (88.4%) were generated from data derived from ILR devices. Of the ILR alerts, 179 (52%) were false positives.
- Other YELLOW alerts were generated from 10 (2.5%) Pacemakers, 11 (2.8%) ICDs and 23 (5.9%) BIVICDs.

Conclusions

- All RED alerts were generated by ICDs and were clinically significant
- The majority of YELLOW alerts were due to ILR downloads
- Automation of remote monitoring is feasible and effective in the management of CIED Clinics

Implications

- Automation can help streamline workflow in CIED clinics
- ILR devices transmit more frequently and have a high rate of false positive rate for alerts
- Data management will be critical to better patient outcomes

PACEMATE™ PRODUCES STREAMLINED WORKFLOW



The Use of a Novel Software-Based Data Management System to Streamline Remote Monitoring Workflow in the Evaluation of Implantable Loop Recorders (ILR)

Kevin R. Campbell, MD, FACC, Noemi Ray, RN, Jason Hale, CCDS

PaceMate™ Sarasota, Florida, USA

Introduction

Remote cardiac monitoring:

- Reduces hospitalizations
- Prevents atrial fibrillation (AF)-related strokes
- Reduce mortality

Implantable loop recorders (ILR) are a large and growing proportion of cardiac implants

ILR devices generate enormous amounts of data

- Data can be vital in preventing morbidity/mortality
- False positives also common

Timely evaluation of data is key to interventions

Most remote monitoring is manual with complicated workflow

Methods

Data obtained from automated remote follow-up of CIEDs utilizing PaceMate™ software technology

30 day data capture window in October/November 2017

Analysis included:

Frequency of events and downloads for all devices and by device type

ILR device false positives adjudicated by IBHRE technician interpretation

Results

1441 patients were followed

253 (17%) ICDs
682 (47%) PMs
182 (12.6%) BIV ICDs
37 (2.6%) BIV PMs
287 (16.4%) ILR

1247 total transmissions were received

719 (57.6%) transmissions due to a perceived event
528 (42.4%) due to routine/scheduled remote follow-up.

ILR: 342 transmissions (27% of all downloads, most by device)
179 false positives (52%)

ILR transmission rate = 144% (1.44 transmissions/device)

Conclusions

ILR were 17% of devices but produced 27% of transmissions

Half of transmissions are triggered by a perceived event

About half the transmissions from ILR devices are true positives

Implications

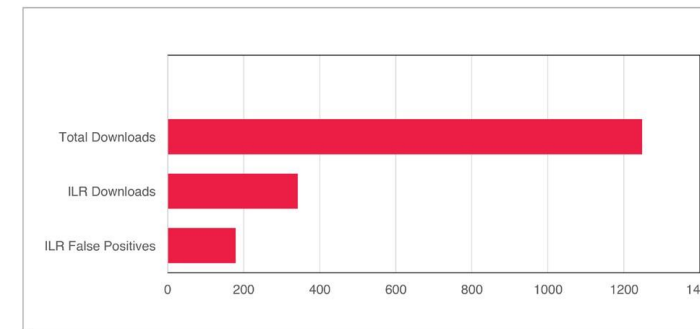
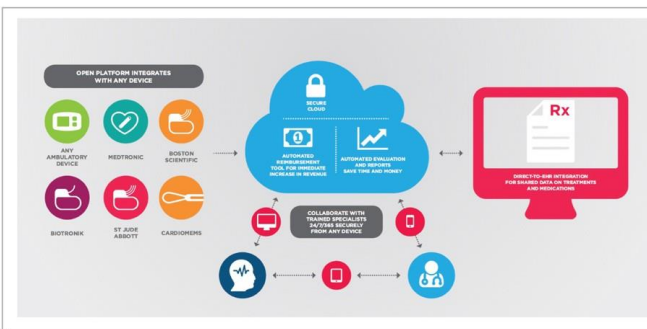
Devices produce large quantities of data, half from potential actionable events.

The volume, as well as downloads occurring after clinic hours present challenges to device clinics

Software-based monitoring can identify and process true events allowing better and more timely monitoring of patients

Purpose

To demonstrate the potential advantages of an automated, software-based solution that employs artificial intelligence (AI) and IBHRE certified techs in the management patients with ILR devices



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SUMMARY

- Digital tools will allow us to better influence and monitor our patients
- Remote monitoring with wearables/loop recorders/other connected devices will likely improve our ability to reduce strokes, improve success in the management of chronic disease, and identify those who need additional treatments or lifestyle modification
- The use of Big Data in medicine will facilitate disease prediction and prevention



SUMMARY

- Remote monitoring is the essence of “digitizing the human being”
- Automation of remote monitoring is critical to data management and allows doctors to do what they do best....take care of patients
- The ideal system COMBINES AI/automation with physician oversight
- Keeping up with this rapidly evolving technology is just as important for physicians as keeping up with new and innovative surgical techniques



Digitizing the Human Being and Optimizing the Digital Ecosystem: The Automation of Remote Monitoring

Kevin R. Campbell, MD, FACC
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Kevin R. Campbell, MD, FACC discusses the importance of automating the remote monitoring process. [continue reading](#)

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In 2012, one of my mentors in the digital space, Dr. Eric Topol, said that monitoring “is the essence of digitizing a human being. For medical purposes, it’s getting all the essential data, and it will be the information to radically transform the future of medicine.”¹ His comments have now become a reality. Over the next 3 years, it is estimated that nearly 20 million patients will be connected to home monitoring devices. This will certainly generate hundreds of terabytes of data — much of which must be processed, interpreted, stored, and most importantly, acted on by a healthcare provider or team. The ability to track real-time information and monitor subtle fluctuations in measurable biologic indicators will likely allow physicians to respond to patient needs much more quickly — often resulting in better care and improved outcomes.

Putting the Patient at the Center of the Digital Ecosystem



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