Remote Patient Monitoring
Hospital-at-Home and other settings

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Technology revolution and Consumerism Impact on Anesthesia, Surgery, Healthcare

Digital Health: Telehealth, AI/Machine Learning, Robotics, Decision support systems, Wearables, Remote Patient Monitoring
Increasing Consumerism
Patient choice
Just in time and when I need it

In 2029, 29% of all E&M visits will be delivered in a virtual care setting.
What is RPM?

In its simplest form, connected health electronic tools to record personal health and medical data in one location that is reviewed by a provider at a different location.

- Different from TeleHealth and Chronic Care Management (platform and patient Eligibility)
Sensors and Systems in RPM

Mechano-electric (Strain and Pressure) Sensors

Bioelectric Sensors

Optoelectric Sensors

Ultrasonic Sensors

Electrochemical Sensors

Neurology
- Wristband/smart watch
- Pulse oximeter

Cardiovascular
- Wristband
- Smart watch
- Chest strap
- Vest
- Chest patch

Pulmonary
- Finger pulse ox
- Abdominal patch

Movement
- Wristband/smart watch
- Shoe insert
- IMU-integrated patches/belts/clips

Metabolic
- CGM
- Smart watch
- Contact lens
- Skin clip
Near future in Digital Tech: AI-Embedded Sensors for Advanced Monitoring and Care Delivery Improvement

AI-embedded Wearable Biosensors for Hemodynamic and Cardiac Diagnostics
Automated Continuous Cardiac Diagnostics

IEEE EMBS Proceedings. 2020 Jul:4067-4070

Cloud/5G and AI enabled miniaturized VR/AR smart glasses

Cell phone enabled Blood Pressure for Remote and Ambulatory Monitoring

Gastric Alimetry for GI disorders

AI-enabled Voice Biomarker RPM for Mental Health
US Remote Patient Monitoring Users, 2020-2025

millions and % change

Note: individuals of any age who use wired or wireless devices that remotely track or collect well-being or medical data from the user outside a traditional healthcare setting at least once per month, and exchange it via the internet with electronic health records accessed by a medical professional or healthcare provider; includes wearable devices, home health devices, and sensors

Source: Insider Intelligence, Aug 2021
### Exhibit 1. Percentage of physicians whose practices have the following modalities and telehealth functions

<table>
<thead>
<tr>
<th>Modalities used in the practice</th>
<th>2018</th>
<th>2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Videoconferencing with patients</td>
<td>14.3%</td>
<td>70.3%</td>
</tr>
<tr>
<td>Videoconferencing with another HCP</td>
<td>11.6%</td>
<td>26.2%</td>
</tr>
<tr>
<td>Store and forward of data</td>
<td>11.9%</td>
<td>13.1%</td>
</tr>
<tr>
<td>Remote patient monitoring (RPM)</td>
<td>10.4%</td>
<td>19.9%</td>
</tr>
<tr>
<td>Phone calls for patient visits</td>
<td>n/a</td>
<td>66.6%</td>
</tr>
</tbody>
</table>

**Function of telehealth in the practice**

| Manage patients with chronic disease     | 9.9%   | 59.2%  |
| Provide care to patients with acute disease | n/a    | 50.4%  |
| Provide preventative care                | n/a    | 34.3%  |
| Diagnose or treat patients               | 15.6%  | 58.0%  |
| After hours care or night calls          | 9.9%   | 22.4%  |

Source: Author’s analysis of the AMA 2018 and 2020 Physician Practice Benchmark Surveys. Notes:
RPM used for both Chronic and Acute conditions that benefit from physiologic monitoring

- Obesity
- Prediabetes
- Diabetes
- Hypertension
- Heart Failure
- Chronic Kidney Disease
- COPD

Outcomes Achieved through RPM (Organizations with a live RPM program; respondents could report multiple outcomes (n=37))

- Reduced health system utilization: 22
- Improved patient outcomes/Interventions offered: 15
- Patients more engaged in their health: 5
- Improved patient satisfaction: 4
- Financial profit: 2
- Too early to tell: 7

38% report reduced admissions
25% cited improved patient satisfaction
25% reported cost reductions.

https://klasresearch.com/962
Reasons for RPM Success

CONNECT.
Connect with patients using today’s consumer and medical devices.

ENGAGE.
Engage with patients using captivating and intuitive programs.

EDUCATE.
Educate patients with current, relevant and informative content.

GUIDE.
Guide patient behavior with outcomes-based clinical pathways.

MONITOR.
Monitor and notify on patient biometrics, activity, and progress along prescribed pathways.

INTERVENE.
Intervene with patients using messaging, video or phone.

Patient Timely Diagnosis and outcomes; Satisfaction
Provider Satisfaction and Engagement
Hospital Capacity and Staffing
Interest from Payors, Costs and Outcomes
Significant Payor Interest in Promoting RPM

United Healthcare Launches Maternal Remote Patient Monitoring Program in Tennessee

- Improve Quality Measures (i.e. HEDIS)
- Reduce the Cost of Maternity Care
- Avoid Complications for Mom and Baby
- Drive Better Compliance to Prenatal and Postpartum Care
- Target Social Determinants of Health

https://mhealthintelligence.com/
CMS Acute Care Hospital at Home Model (2020)

Patients admitted to the program from emergency departments and inpatient hospital beds

Hospital-level care at home with continuous and passive monitoring designed for high-acuity patients. Response to emergencies.

- Pharmacy
- Infusion (IV push and IV Piggyback infusions)
- Respiratory care (oxygen delivery, nebulizer treatment, etc.)
- Diagnostics (labs, radiology)
- Monitoring with at least 2 sets of patient vitals daily (must include heart rate, blood pressure, respiratory rate, oxygen saturation, and temperature)
- Transportation of patients (ambulance, non-ambulance medical transport, other)
- Food services (including meal availability as needed by the patient)
- Durable medical equipment (e.g., commode chair, walker, cane, hospital bed)
- Physical, occupational, and speech therapy
- Social work and care coordination

Patients stay connected to their care teams with on-demand call/video and messaging.

Deliver in-home services, as needed


https://www.currenthealth.com
UPMC Innovative Homecare Solutions (UIHS) (501-3C)

- Connected Care
- Advanced Illness Care
- In Home Acute Care
- Member
- PCP
- Digital Health Tools
- Wearables, sensors
- Call bell
- Care Management
- Expanded Capabilities
- Expert D/C Planner
- Purple Card
- Health Plan CM
- AWC
- Specialist
- Home Health

UPMC LIFE CHANGING MEDICINE
<table>
<thead>
<tr>
<th>Outcome</th>
<th>Average Treatment</th>
<th>P-value</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>7-day ED Return</td>
<td>-3.67%</td>
<td>0.000</td>
<td>-4.40%</td>
</tr>
<tr>
<td>30-day ED Return</td>
<td>-10.19%</td>
<td>0.000</td>
<td>-12.56%</td>
</tr>
<tr>
<td>90-day ED Return</td>
<td>-10.52%</td>
<td>0.009</td>
<td>-18.37%</td>
</tr>
<tr>
<td>7-day IP Readmission</td>
<td>-3.57%</td>
<td>0.001</td>
<td>-5.70%</td>
</tr>
<tr>
<td>30-day IP Readmission</td>
<td>-7.03%</td>
<td>0.000</td>
<td>-10.65%</td>
</tr>
<tr>
<td>90-day IP Readmission</td>
<td>-10.63%</td>
<td>0.001</td>
<td>-17.11%</td>
</tr>
</tbody>
</table>

Effect of Remote Monitoring on Discharge to Home, Return to Activity, and Rehospitalization After Hip and Knee Arthroplasty

A Randomized Clinical Trial

Table 2. Hospitalization/Discharge and Use Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Intervention (n = 118)</th>
<th>Control (n = 124)a</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Discharge to home, No. (%) [95% CI]</td>
<td>67 (56.8) [47.9-65.7]</td>
<td>71 (57.3) [48.5-65.9]</td>
<td>.95</td>
</tr>
<tr>
<td>Length of hospital stay, mean (SD), d</td>
<td>2.5 (1.0)</td>
<td>2.5 (1.3)</td>
<td>.96</td>
</tr>
<tr>
<td>Time at home, median (IQR), d</td>
<td>42 (34-43)</td>
<td>42 (33-43)</td>
<td>.64</td>
</tr>
<tr>
<td>Rehospitalization rate, No./total No. (%) [95% CI]</td>
<td>4/118 (3.4) [0.1-6.7]</td>
<td>15/123 (12.2) [6.4-18.0]</td>
<td>.01</td>
</tr>
<tr>
<td>Rehospitalizations, total No. (%) [95% CI]</td>
<td>5 (4.2) [0.6-7.9]</td>
<td>16 (13.0) [7.1-19.0]</td>
<td>.02</td>
</tr>
<tr>
<td>Observationc</td>
<td>1 (0.8)</td>
<td>1 (0.8)</td>
<td></td>
</tr>
<tr>
<td>Inpatientc</td>
<td>4 (3.4)</td>
<td>13 (10.5)</td>
<td></td>
</tr>
<tr>
<td>Patients with 2 rehospitalizations</td>
<td>1 (0.8)</td>
<td>1 (0.8)</td>
<td></td>
</tr>
<tr>
<td>Admissions from ED</td>
<td>2 (1.7)</td>
<td>9 (7.3)</td>
<td></td>
</tr>
<tr>
<td>Joint-related rehospitalizations</td>
<td>1 (0.8)</td>
<td>7 (5.6)</td>
<td></td>
</tr>
</tbody>
</table>
Can Remote Patient Monitoring Improve Post-Surgical Care and Recovery?

Post-discharge after surgery Virtual Care with Remote Automated Monitoring-1 (PVC-RAM-1) technology versus standard care: randomised controlled trial. *BMJ* 2021
Remote Patient Monitoring and Decision Support in the Hospital

A Remote Surveillance Platform to Monitor General Care Ward Surgical Patients for Acute Physiologic Deterioration

Kyan C. Safavi, MD, MBA,* Hao Deng, PhD,*† William Driscoll, MA,† Milcho Nikolov, MA,* Kalpan Tolia, MA,* and Jeanine P. Wiener-Kronish, MD*

Patch validation: an observational study protocol for the evaluation of a multisignal wearable sensor in patients during anesthesia and in the postanaesthesia care unit

BMJ Open 2020;10:e040453

Morgan Le Guen,1 Pierre Squara 2 Sabrina Ma,1 Shérifa Adjavon,1 Bernard Trillat,2 Messaouda Merzoug,2 Philippe Aegerter,2,3 Marc Fischler 2 1

Oxygen saturation, respiratory rate, heart rate, body temperature and blood pressure
Decision Support Engine

Monitoring and Surveillance Clinical Decision Support Systems:
AW Multifunctional Monitor

AIMS
LABS
H & P
AI and Computer Vision Monitoring (and Guiding) Anesthesia and Surgery Performance

Context:
- Microphones and Camera
- Patient Intracorporeal Data
- Captures, identifies, labels, organizes and analyzes data to guide performance
- OR Devices Data
- Patient EMR Data
- Teamwork, Quality, Compliance, Safety, Training, Efficiency

Surgical Safety Technologies
OR Black Box

Contextual Analytics

https://www.surgicalsafety.com
Challenges and Limitations to Overcome for RPM

- Accuracy
- Privacy and Security
- Oversight
- Accessibility
- Cost
- Acceptability
- Technological/ Form Factor
- Lack of Standards
- Scientific peer-reviewed evidence for safety and efficacy in all clinical settings NOT established

For Anesthesiology and its practices (Preoperative, Post-operative, Pain, post-ICU, others): Challenge to adapt to shifting healthcare landscape

Need for Evidence generation, Adoption, Training, in current and future clinical practice models

9/14/2022
Not yet, but maybe soon

“You can’t list your iPhone as your primary-care physician.”

Thank You