NHIS GLOBAL FORUM 2025

The Wearable Revolution: The Future of Smart Healthcare Driven by AI and Data-Powered Medical Devices

Seung-Jin Oh. MD / NHIS Ilsan hospital

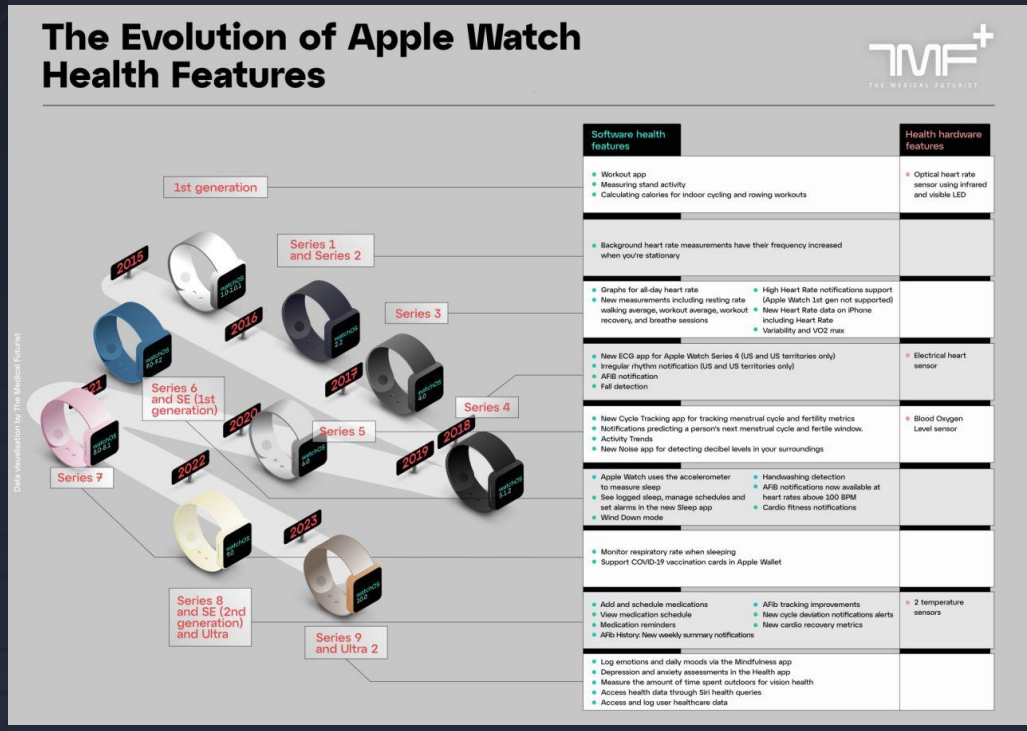
Wearables

Digital Biomarker

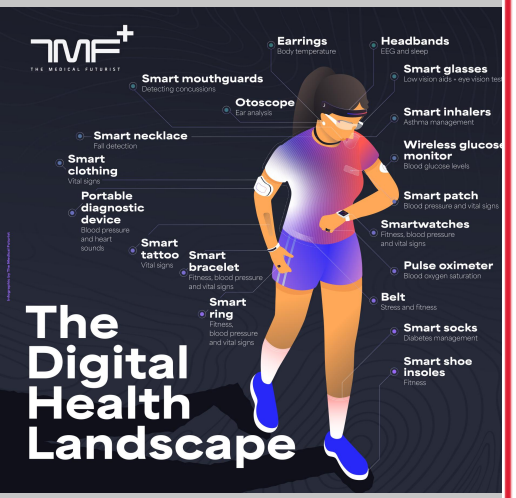
4P Medicine (Predictive, Preventive, Personalized, Participatory)

Wearables for Wellness

for Lifestyle modification



The Evolution of Apple Watch

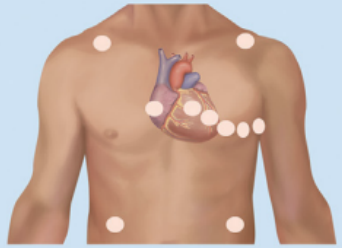


CENTRAL ILLUSTRATION Diagnostic Accuracy of Apple Watch Electrocardiogram for Atrial Fibrillation: A Systematic Review and Meta-Analysis

Apple Watch ECG

VS

Standard 12-Lead ECG



Systemic Literature Search

- PubMed
- Embase
- Cochrane Library

11 studies in the meta-analysis

4,241 participants with 28% females

Sensitivity: 94.8%

Specificity: 95%

Area under curve: 0.96%

Detection of atrial fibrillation

Conclusion:

Apple watch ECG carries high accuracy in defecting atrial fibrillation, providing a convenient diagnostic option for patients

Shahid S, et al. JACC Adv. 2025;4(2):101538.

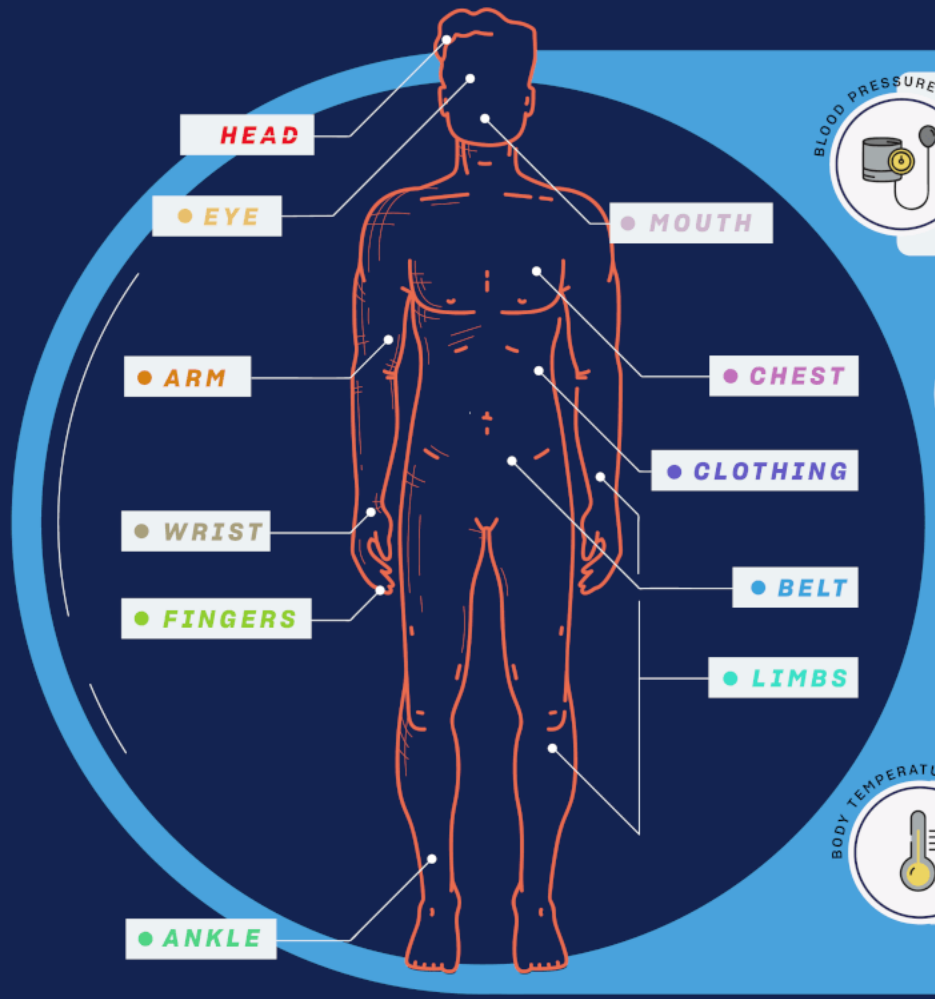
ECG = electrocardiogram.

	Health hardware features
workouts	• Optical heart rate sensor using infrared and visible LED
equency increased	
n Heart Rate notifications support ple Watch 1st gen not supported) v Heart Rate data on iPhone uding Heart Rate ability and VO2 max	
S territories only) only)	• Electrical heart sensor
cle and fertility metrics cycle and fertile window. surroundings	• Blood Oxygen Level sensor
dwashing detection notifications now available at rt rates above 100 BPM dio fitness notifications	
at	
tracking improvements v cycle deviation notifications alerts v cardio recovery metrics	• 2 temperature sensors
app • Depression and anxiety assessments in the Health app • Measure the amount of time spent outdoors for vision health • Access health data through Siri health queries • Access and log user healthcare data	

Data visualization by The Medical Futurist

Wearables for Healthcare

Diagnosis, Treatment, and Management for Disease
Require medical device certification for Clinical decision making



BLOOD PRESSURE
- Withings
- iHealth
- MocaCare
- Omron

EEG
- Muse
- Brainlink

MOTION + HEART RATE
- Fitbit
- Garmin
- Polar
- Apple
- Withings
- Ticwatch
- Wahoo
- Oura

ECG
- Kardia
- WIWE
- Withings

BREATHING
- Spire
- AioCare

COMBINED DEVICES
- Withings BPM Core
- Viatom+

SLEEP
- Fitbit
- Withings
- Apple
- Beddit
- Resmed
- Oura
- Philips

ELECTRODERMAL ACTIVITY
- Empatica

BODY WEIGHT
- Fitbit
- Withings

BODY TEMPERATURE
- Empatica
- Oura
- Viatom

VISION
- EyeQue
- D-Eye

STETHOSCOPE
- EKO
- WITHINGS

Data visualization by The Medical Futurist


Telehealth
국민건강보험
National Health
Insurance Service
일산병원
Ilsan Hospital

TeleMedicine vs. TeleHealth

based on Technology

Synchronous Asynchronous "store-and-forward"

TeleHealth

TeleMedicine

Video conferencing

Telephone conferencing

Text conferencing

2nd opinion

On-demand prescription

Data analysis

Remote Patient Monitoring

Tele-Surgery

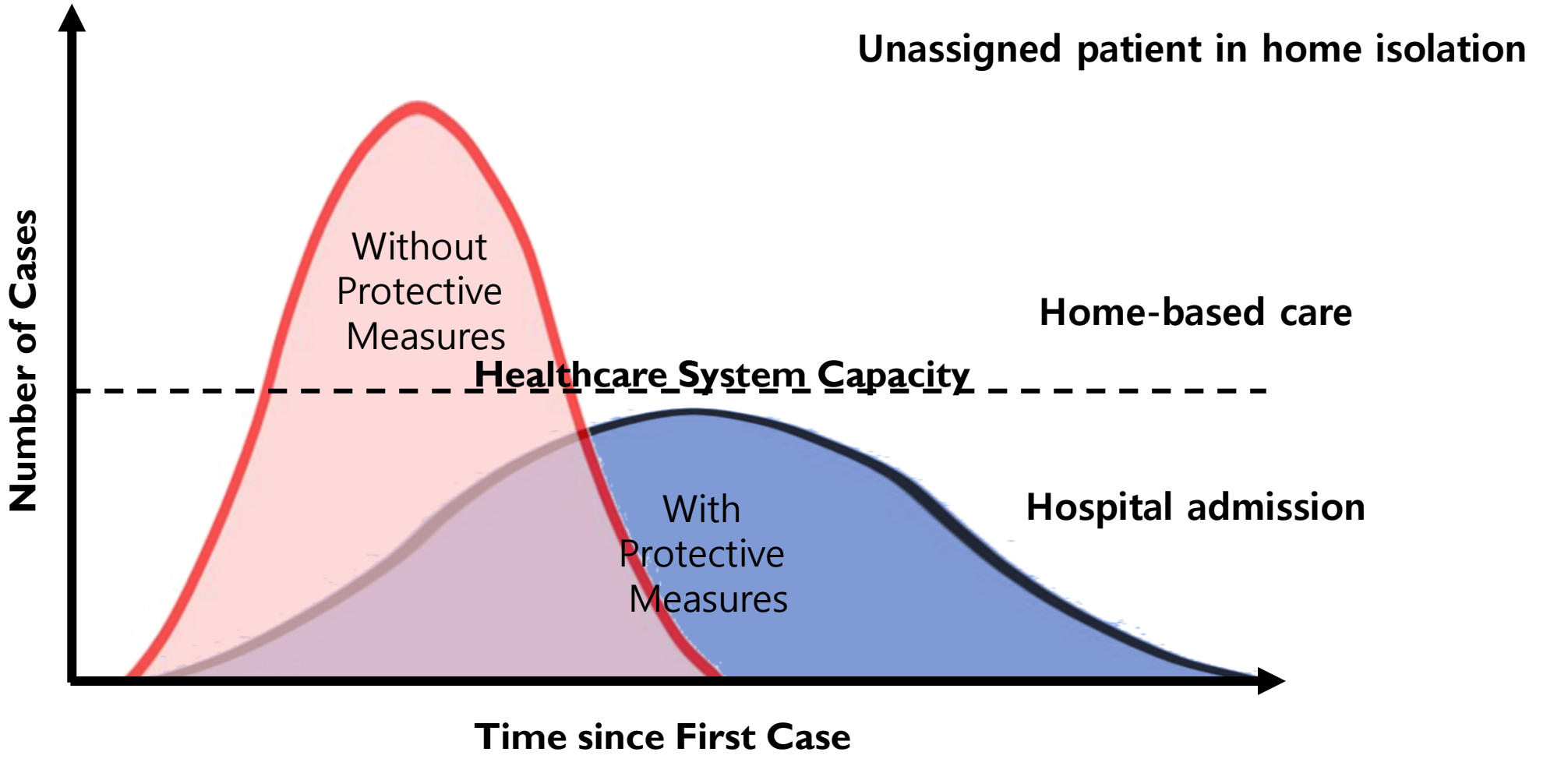
Tele-Radiology

Tele-ICU

Decentralized Clinical Trial

5,000 persons/day Vs. 20,000 persons/day

TeleMedicine after COVID 19



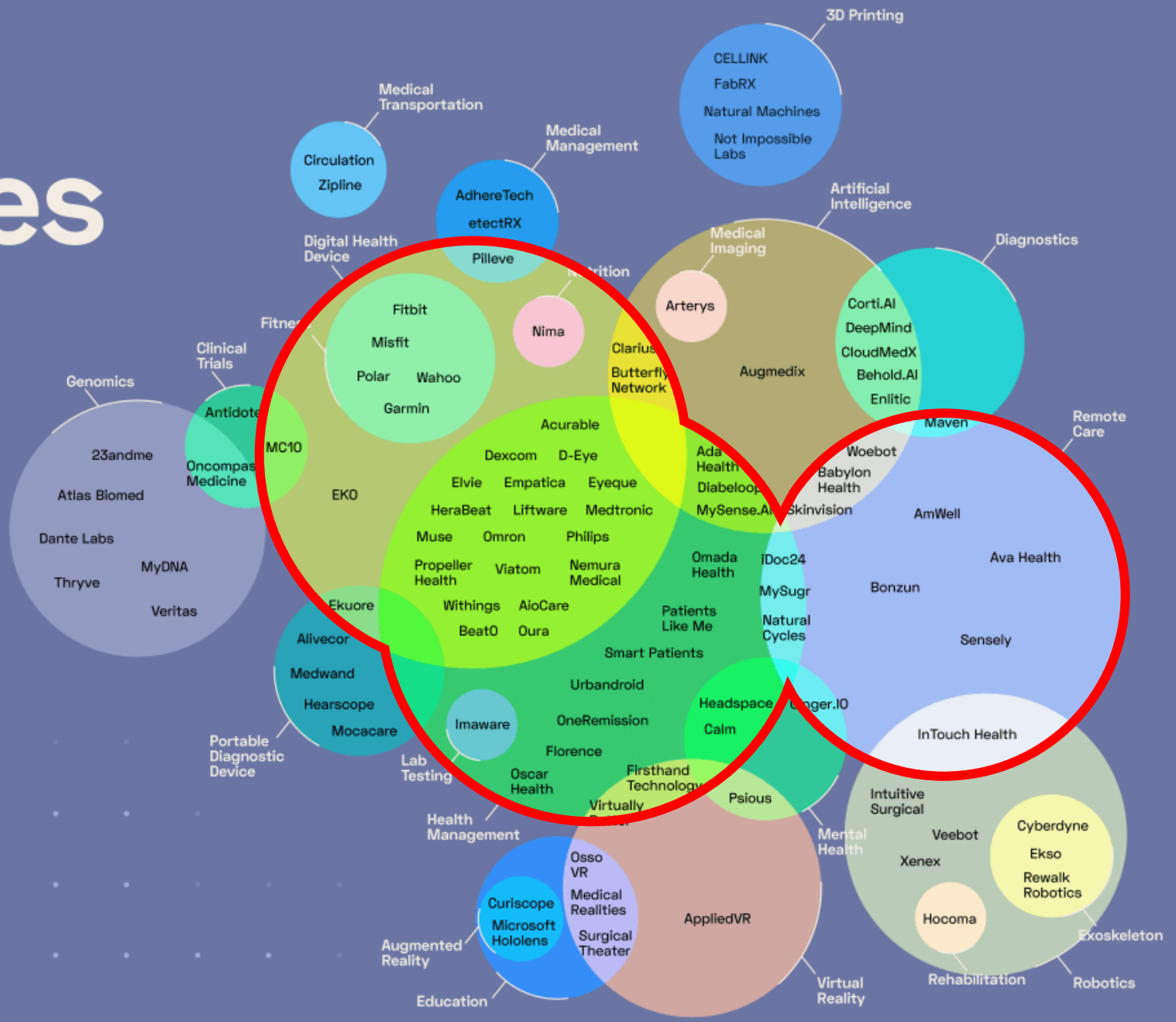
TeleMedicine after COVID 19

Virtual care and outpatient options show more potential revenue growth through 2022.

[1]Compound annual growth rate.
Source: McKinsey analysis

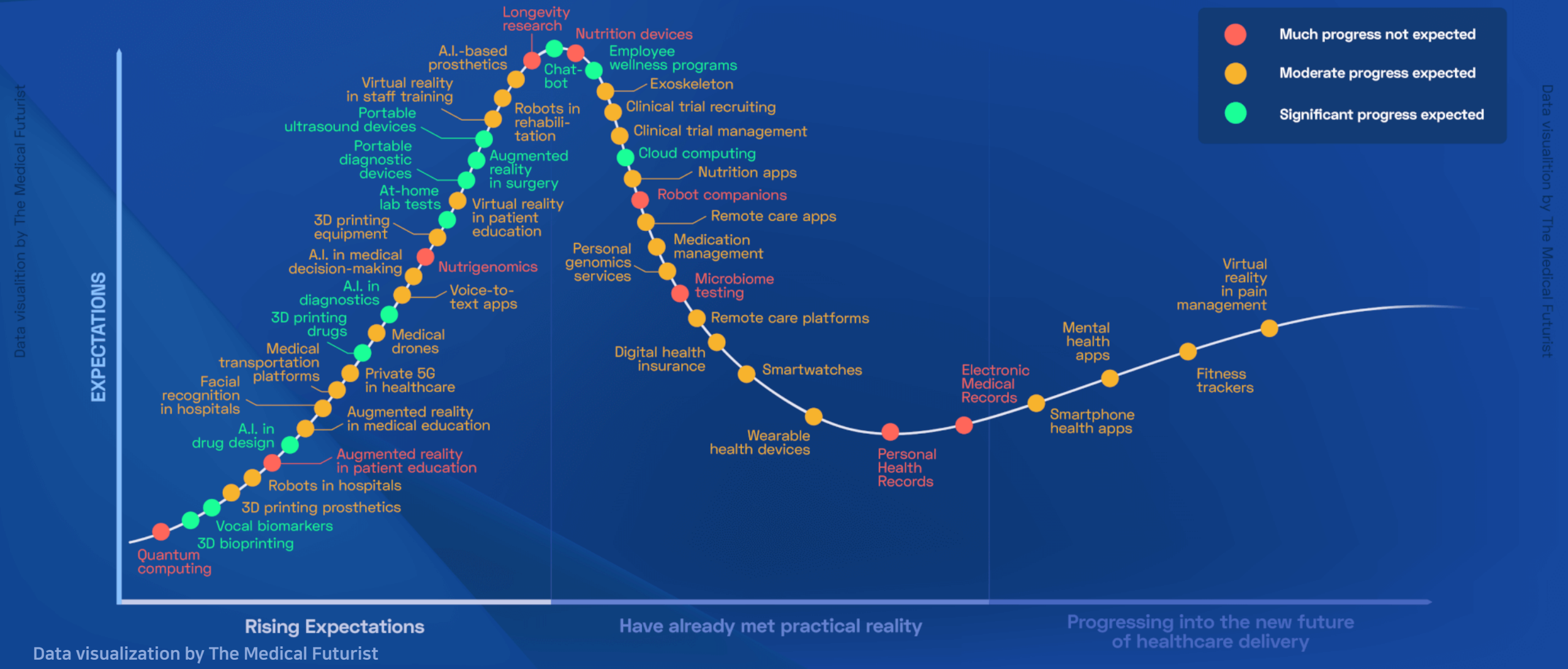
McKinsey & Company

Top 100 Companies 2020



Data visualization by The Medical Futurist

Hype Cycle Of The Top 50 Emerging Digital Health Trends

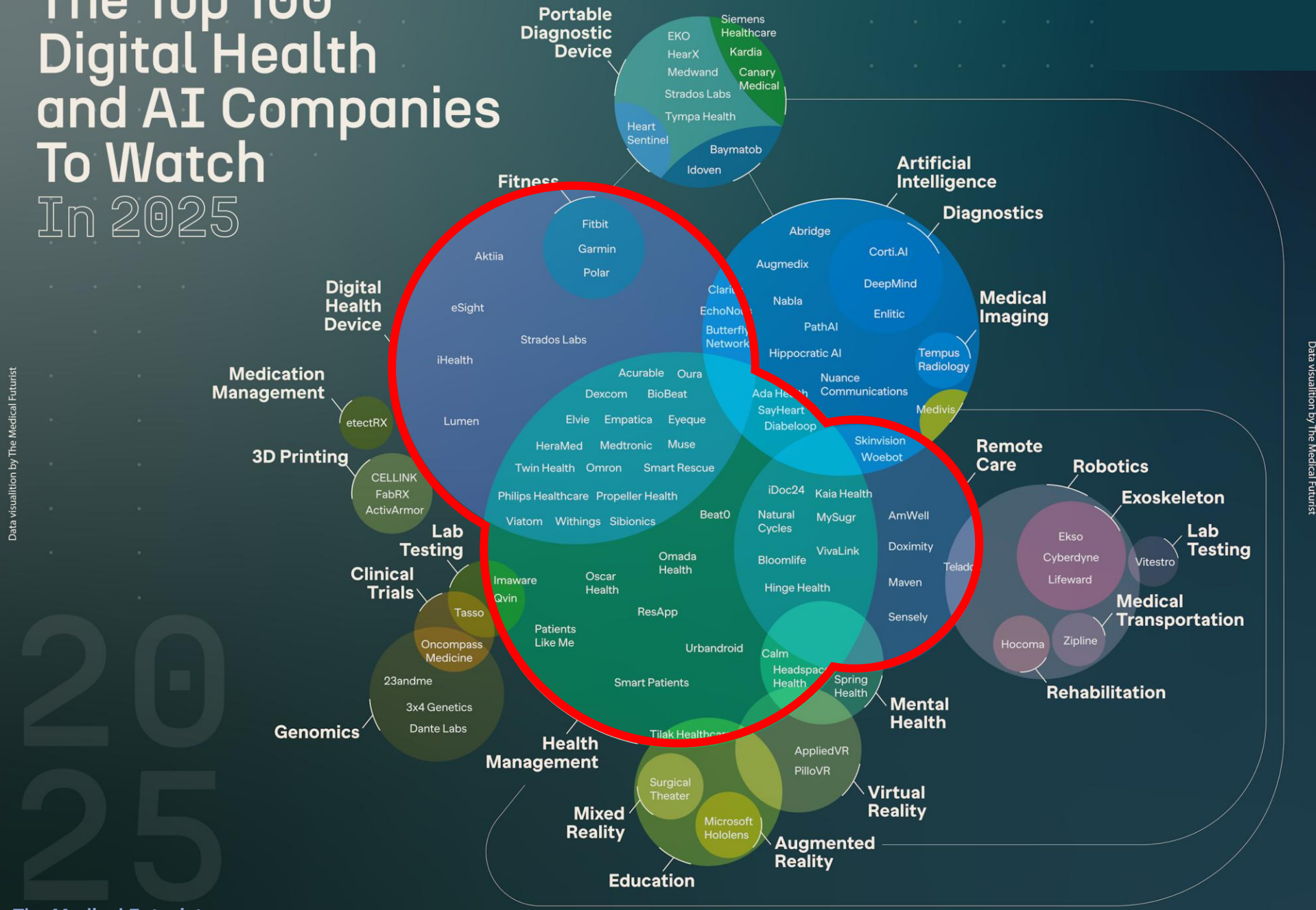


Data visualition by The Medical Futurist

Data visualition by The Medical Futurist

Data visualization by The Medical Futurist

The Top 100 Digital Health and AI Companies To Watch In 2025



Data visualization by The Medical Futurist

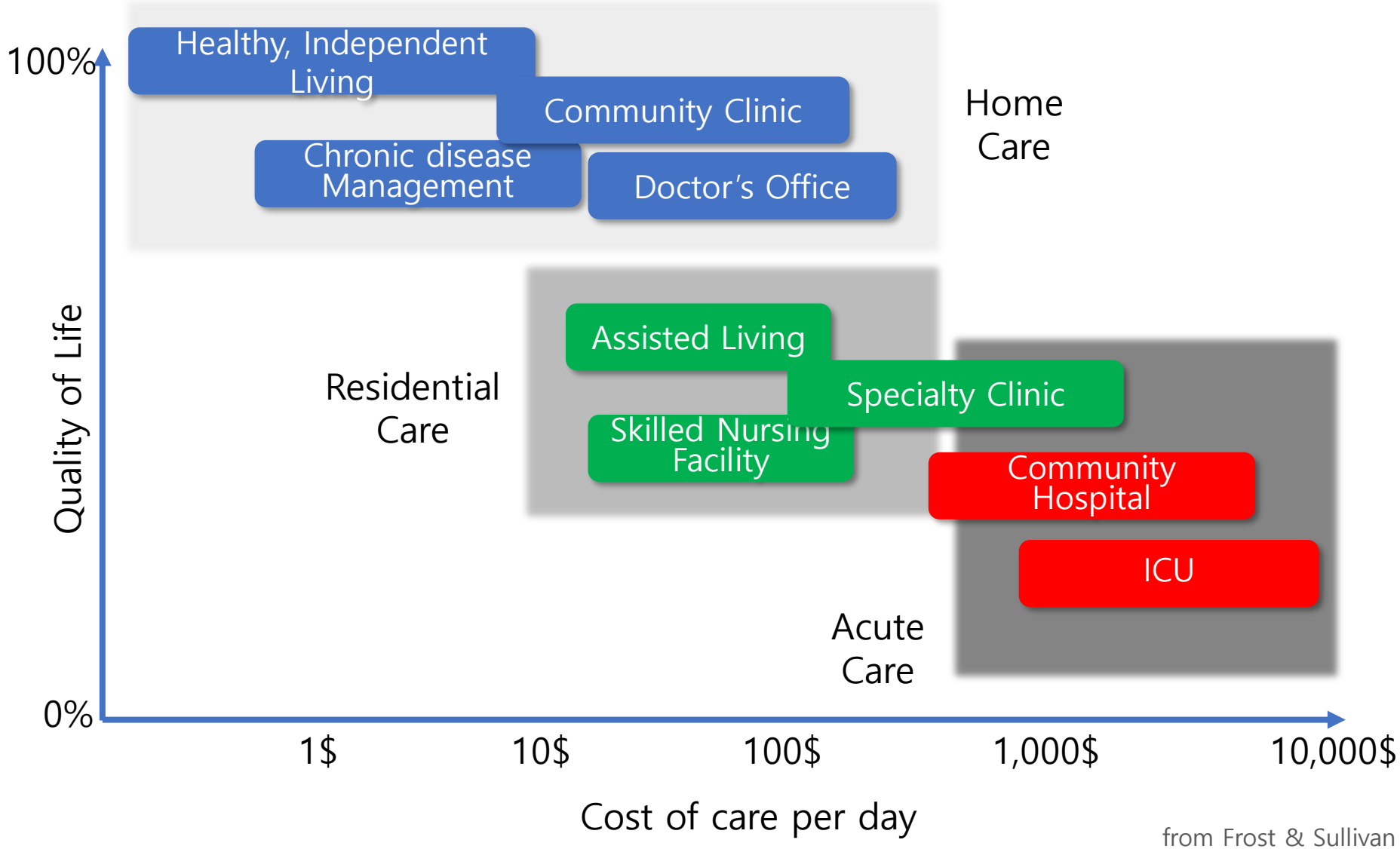
F1RST

CES® Consumer Technology Association™

Abbott
life. to the fullest.


10:23 PM
My Glucose
1m ago
GLUCOSE IN RANGE
6.2
mmol/L

Why do we need RPM ?



from Frost & Sullivan

real time

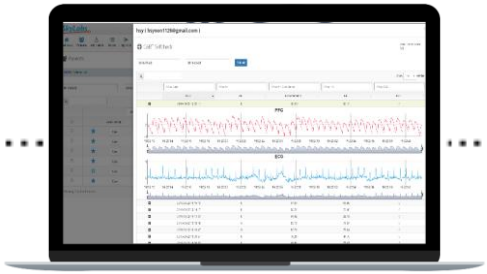
RPM

emote atient onitoring

What is needed for rt-RPM

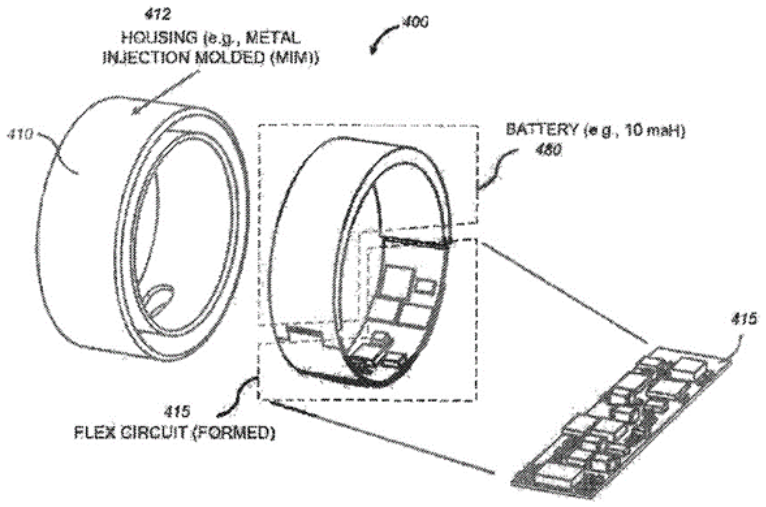
Wearable Device

Mobile App



Cloud Server
AI algorithms

Monitoring Staff



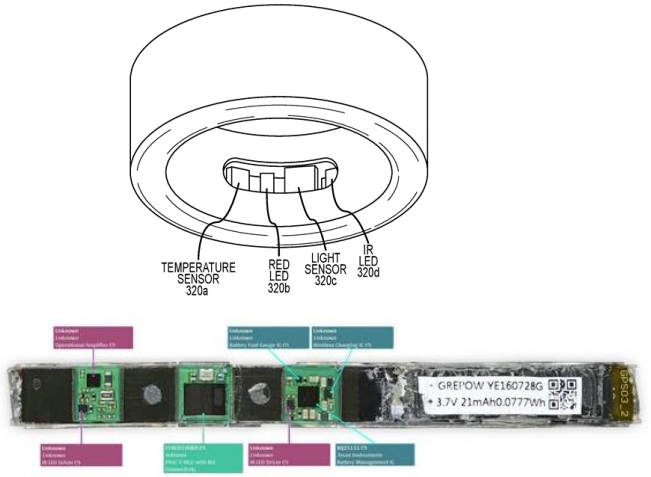
Sensors

MCU/Processor

Wireless Connectivity

Battery & Power

Form Factor & Design



real time, continuous

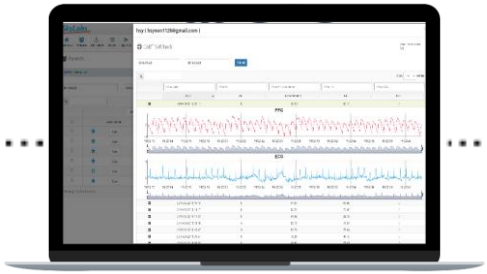
Triage

“draw or choose, after examination.”

What is needed for rt-RPM

Wearable Device

Mobile App



Cloud Server
AI algorithms

Monitoring Staff

Alarm fatigue

Hallucination

Data overload

Anomaly detection
Signal filtering

Predictive modeling
Context integration

Feature attribution (SHAP, LIME)
Counterfactual explanation
Chain-of-Thought (CoT)

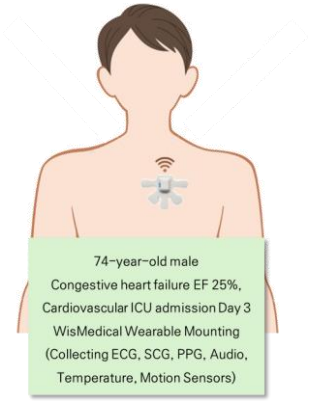
Quantization, Pruning
SoC, NPU, AI module
TFLite, ONNX Runtime

Actionable Ai

Explainable Ai

Edge Ai

eXplainable AI on wearable



1. Real-time multimodal data collection

[Examples of collected data]
Heart rate (ECG): 102 bpm (uptrend)
Cardiac output index (SCG): 22% decrease compared to baseline
Pulse wave propagation velocity (PPG): Estimated increase in peripheral resistance → upward
S3 Heart Sound Strength (Audio): +30% vs. baseline
Posture/movement: Mostly supine, no nighttime position change
Skin temperature: 36.8˚C (normal category)

2. XAI Application

[SHAP Analysis-Explanation of Major Factors Contributing to Decision-making]
SHAP VALUE based on priority..
1. **SCG-based systolic time reduction (△SCG-STS)** → SHAP +0.28
2. Increased heart rate (△HR) → SHAP +0.21
3. **S3 Heart Sound Increase** → SHAP +0.18
4. **PPG Waveform Delay** → SHAP +0.12
5. Others (posture, temperature, etc.)→SHAP ±0.01 or lower
[Prediction Results] "Decreased mechanical contractility + increased heart rate + increased auscultation abnormal sound" was a key factor in the increase in worsening risk scores

[Counterfactual explanation (What if it was different?)]
Counterfactual scenario presented:
"If your current heart rate is **90 bpm or less** and your cardiac output is at the baseline level,
→ risk score would have dropped to 0.42."
→ medical staff intuitively understand which factor control could dismiss the alarm


Benefits

Who will benefit from the telehealth

AS-IS

- Direct patient measurement twice daily
  Body temperature, oxygen saturation
- Twice a day manually entered by patients
  Possible typing errors
  Landline call without input
  If you can't make a call, visit your home
- Patient care Passive monitoring by medical staff
  Individual patient-specific monitoring
- Patient care medical staff manually identify signs
  Possible time delay
- Not reflected

FLOW

Measurement of vital signs

Vital sign input

monitoring

Anomaly alarm

Reflection of treatment results

TO-BE

- Real-time continuous automatic measurement
  Blood pressure, pulse, oxygen saturation
- Real-time continuous auto-entry
  No typing errors
  No input
  Signal error and network error may occur
- Algorithm-based automated monitoring
  Monitoring of entire patient populations
- After identifying algorithm-based automatic alarms
  Real-time delivery to medical staff
- Real-time algorithm
  automatically reflected

Rt RPM during COVID pandemic

01 Raw Data

Data analysis

02 Analysis Results

03 Intervention

Postvaccination at NHIMC Anomaly Monitoring
21.3.10~21.3.26

Patients	Data	
1,001	HR	804,804
	SPO2	391,391
	BP	27,895

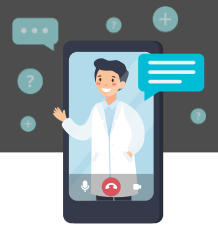
Safe quarantine accommodation in Goyang
21.4.28~21.5.31

Patients	Data	
84	HR	45,032
	SPO2	26,156
	BP	1,553
	BT	28,054

Infection control Hub Hospita
l21.5.17~21.5.31

Patients	Data	
66	HR	52,470
	SPO2	35,457
	BP	1,887
	BT	197,213

Abnormal Signals	Adverse reactions
108	30
2	13
4	34



SMS	Call
426	21
50	30
Real-time moderation	

What is needed for rt-RPM

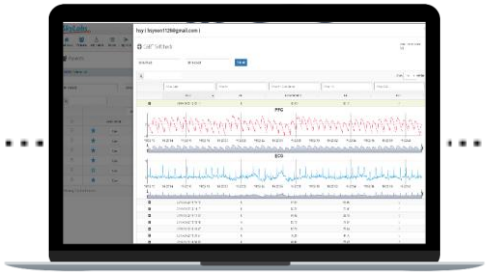
Data accuracy & fidelity

Connectivity reliability
Low latency

Real-time interpretation & response
Data security & Privavy

Wearable Device

Mobile App



Cloud Server
AI algorithms

Monitoring Staff

-30%

-20%

+5min

+5min

~ +6hr

What is needed for rt-RPM

From Dec 23, 2024 95 patients enrolled

Latency

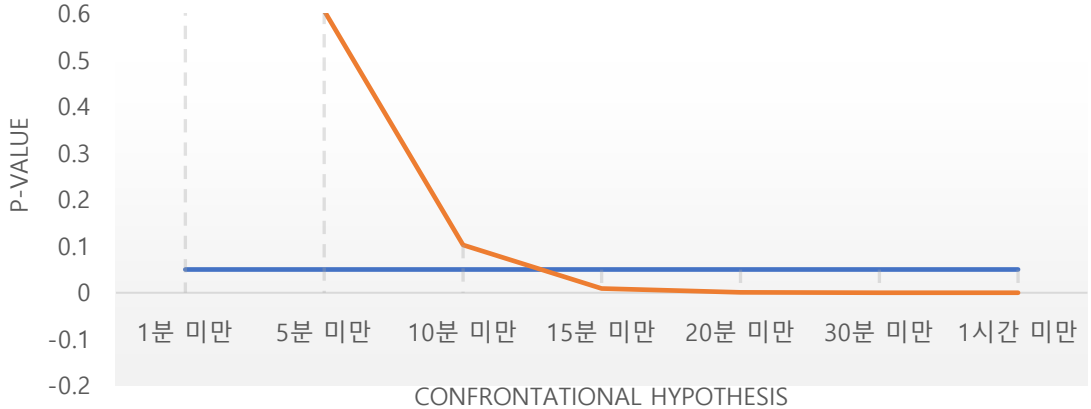
Hypothesis 1. Is it real-time RPM with a dedicated mobile phone APP method?

Primary endpoint = (A-B),

A : Time signal acquired,

B : Time signal delivered to the server

H_0 : A-B ≥δ min. vs. H_1 : A-B < δ min.



Connectivity

Hypothesis 2. Does the 24-hour signal acquisition rate (SAR) exceed 0.81 (0.9×0.9)?

$$\text{Signal acquisition rate (\%)} = \frac{\text{Number of effective signals collected}}{\text{Number of times from wearing time}} \times 100$$

H0 : SAR ≤ 80% vs. H1 : SAR > 80%

Average SAR = 83.7% (p=0.35)

National Health Insurance Service Ilsan Hospital

One & Only
Insurer's hospital
In South Korea

+

Regional Hub hospital
responsible for
2M citizen

=

국민건강보험 일산병원
National Health Insurance Service Ilsan Hospital

NHIC
Ilsan hospital

Mission

Health insurance model hospital that leads people's healthy lives and right medical standards

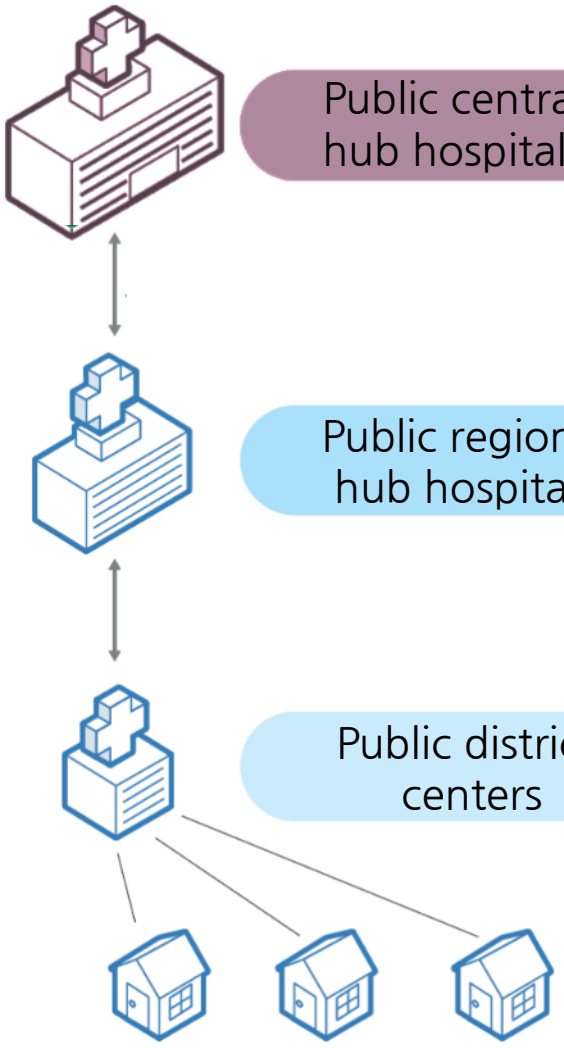
Core Values

Patient centered

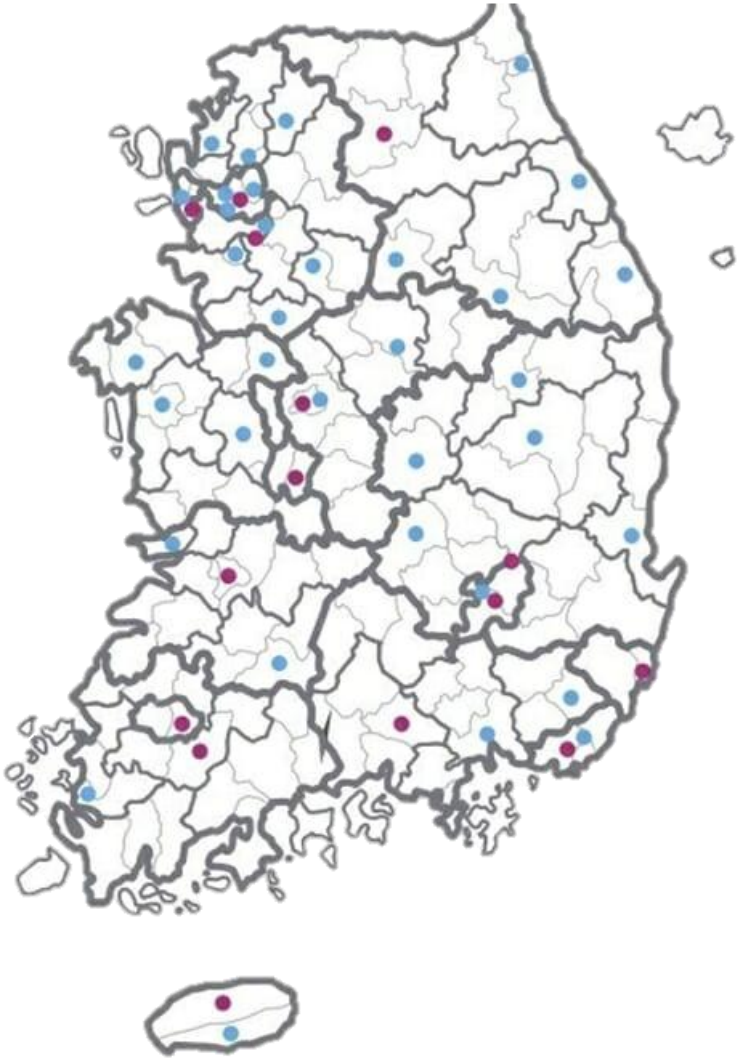
Outstanding expertise

Happy workplace

National Health Insurance Service Ilsan Hospital



		EMC	CCVC	MCHC
Public central hub hospitals	15	42	14	12
Public regional hub hospitals	35	137	10	33
Public district centers				



All-in-One Wearable under development

World's First continuous monitoring wearable capable of 6 major vital signs

(Blood pressure, Heart rate, Respiratory rate, Body temperature, Blood oxygen level, Arrhythmia)

All-in-One Wearable under development

World's First continuous monitoring wearable capable of 6 major vital signs

(Blood pressure, Heart rate, Respiratory rate, Body temperature, Blood oxygen level, Arrhythmia)

IR Sensor

- Body temperature

PPG Sensor

- Other vital signs

All-in-One Wearable under development

All-in-One Wearable under development

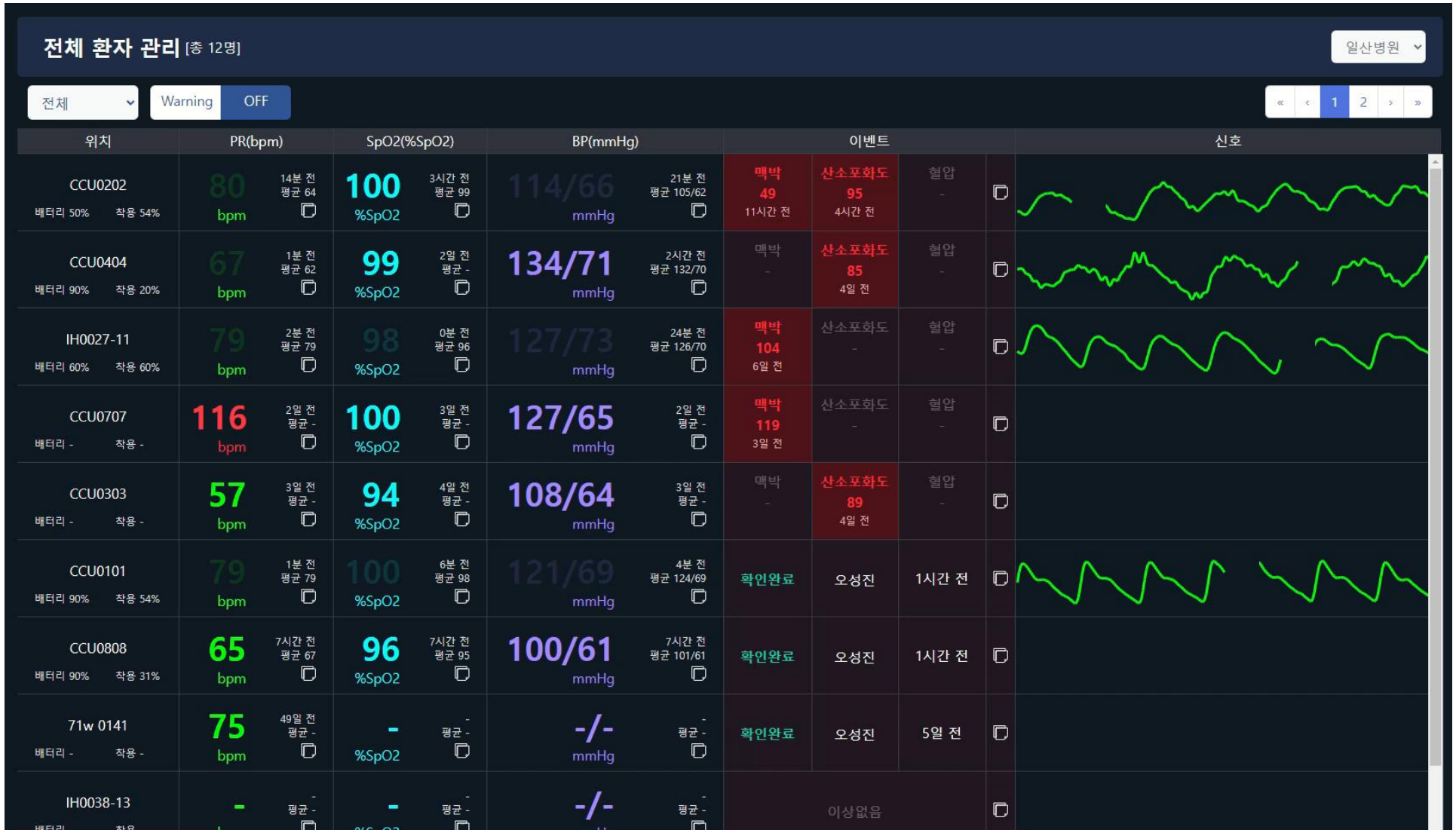
Portable Smart gateway

- Utilizing eSIM – Just turn on, It works
- Video, Phone call, Display dashboard
- All-in-One portal for TeleHealth

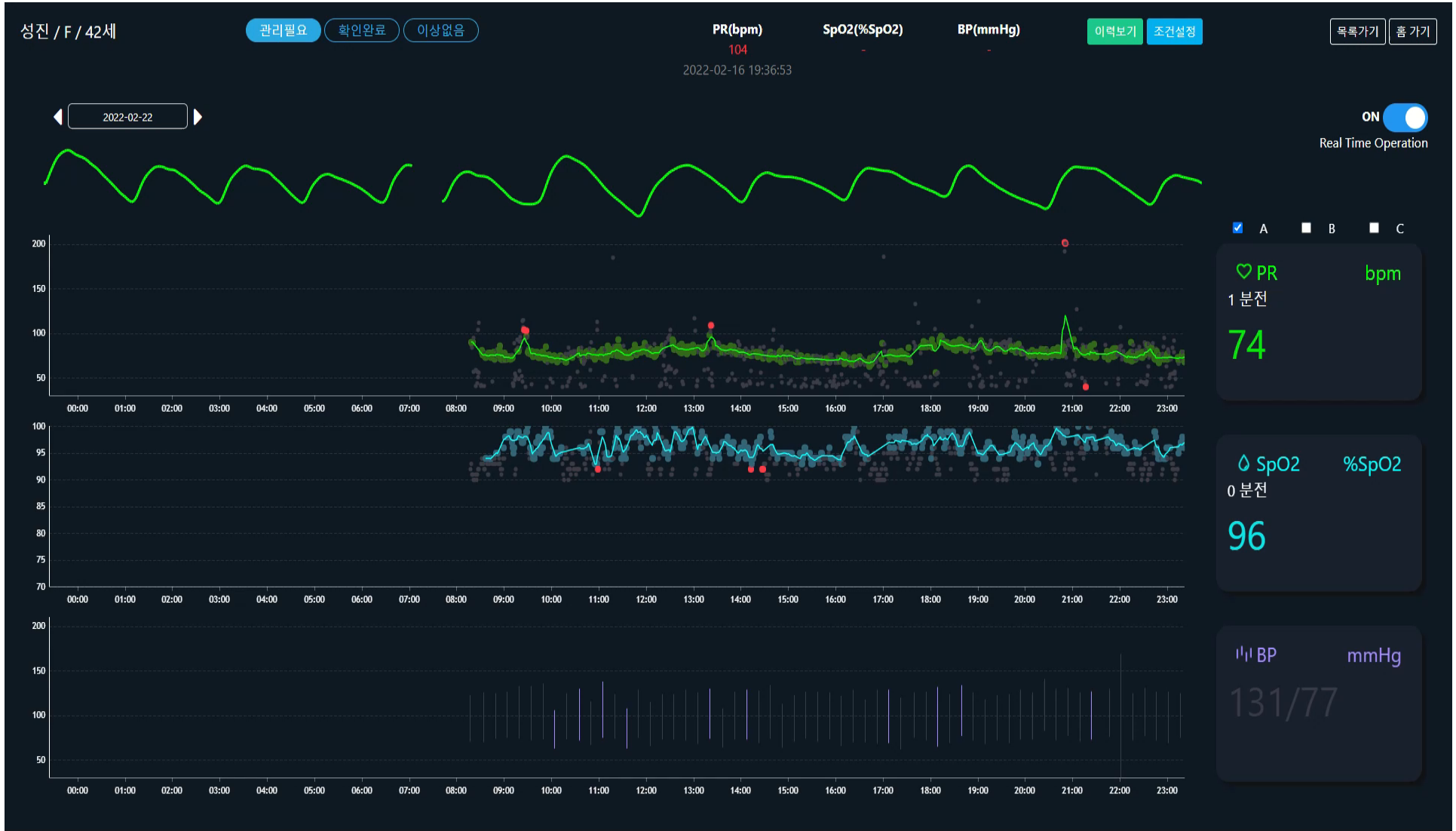
Wrist band

- Temperature Self-check through additional IR sensor
- Capable of vibration alarm
- 7days of Battery life

All-in-One Wearable under development

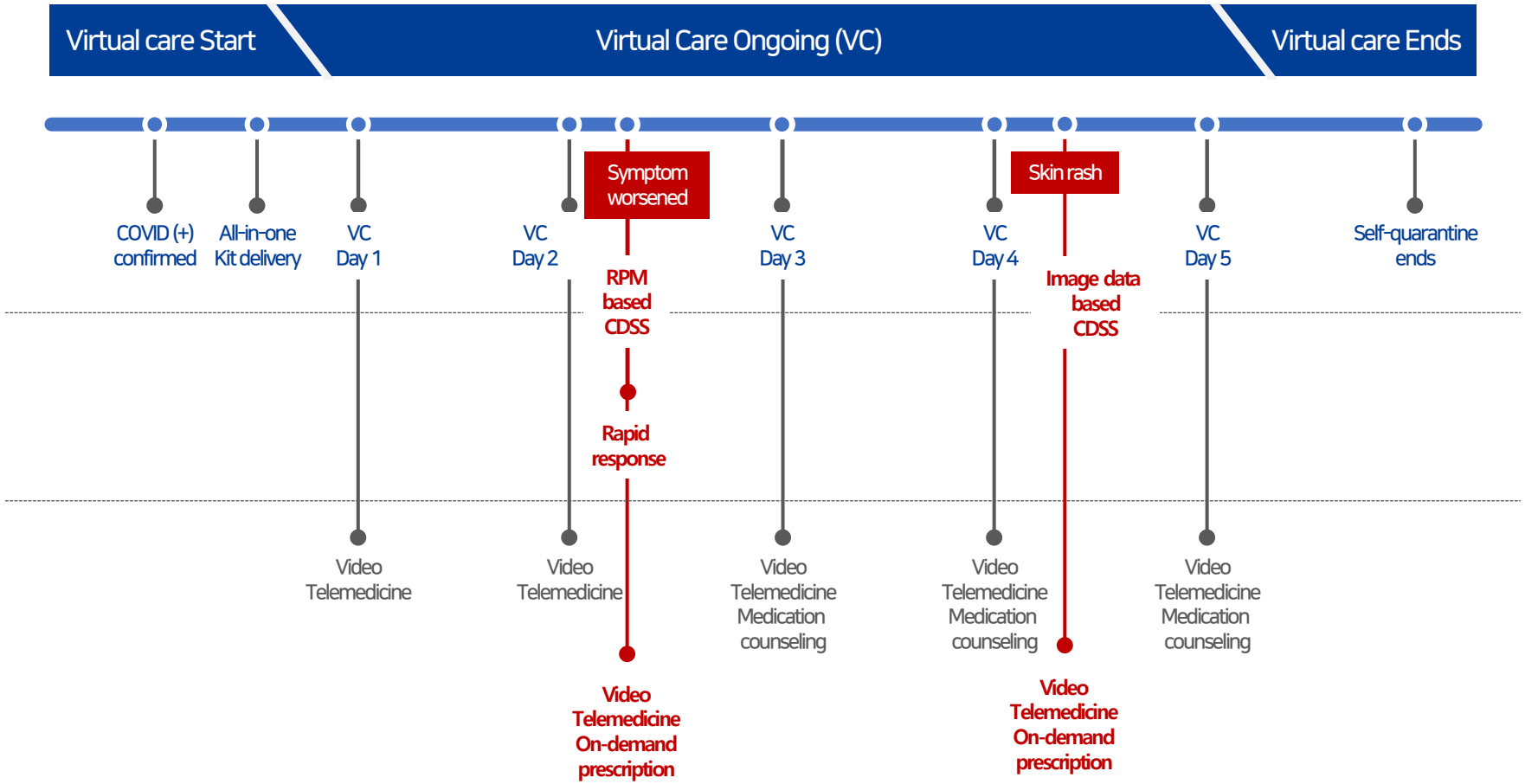


All-in-One Wearable under development



All-in-One Wearable Service model scenario

Not only for infectious disease like COID 19, also for chronic disease



CART Vital (Project ‘Apollon’)

Smart Ring Co-developed with NHIS Ilsan hospital

Awarded the 2025 CES Innovation Award

CES Innovation Awards 2025 Honoree

USA TODAY's 50 Top Picks for CES 2025

[US Today 주목제품 선정]

RESEARCH AFFILIATES | SkyLabs | NHIS Ilsan Hospital | People & Technology

Community-based rapid response system

with Digital healthcare

AI algorithm

+ Imaging analysis
+ real time RPM

Wearable device

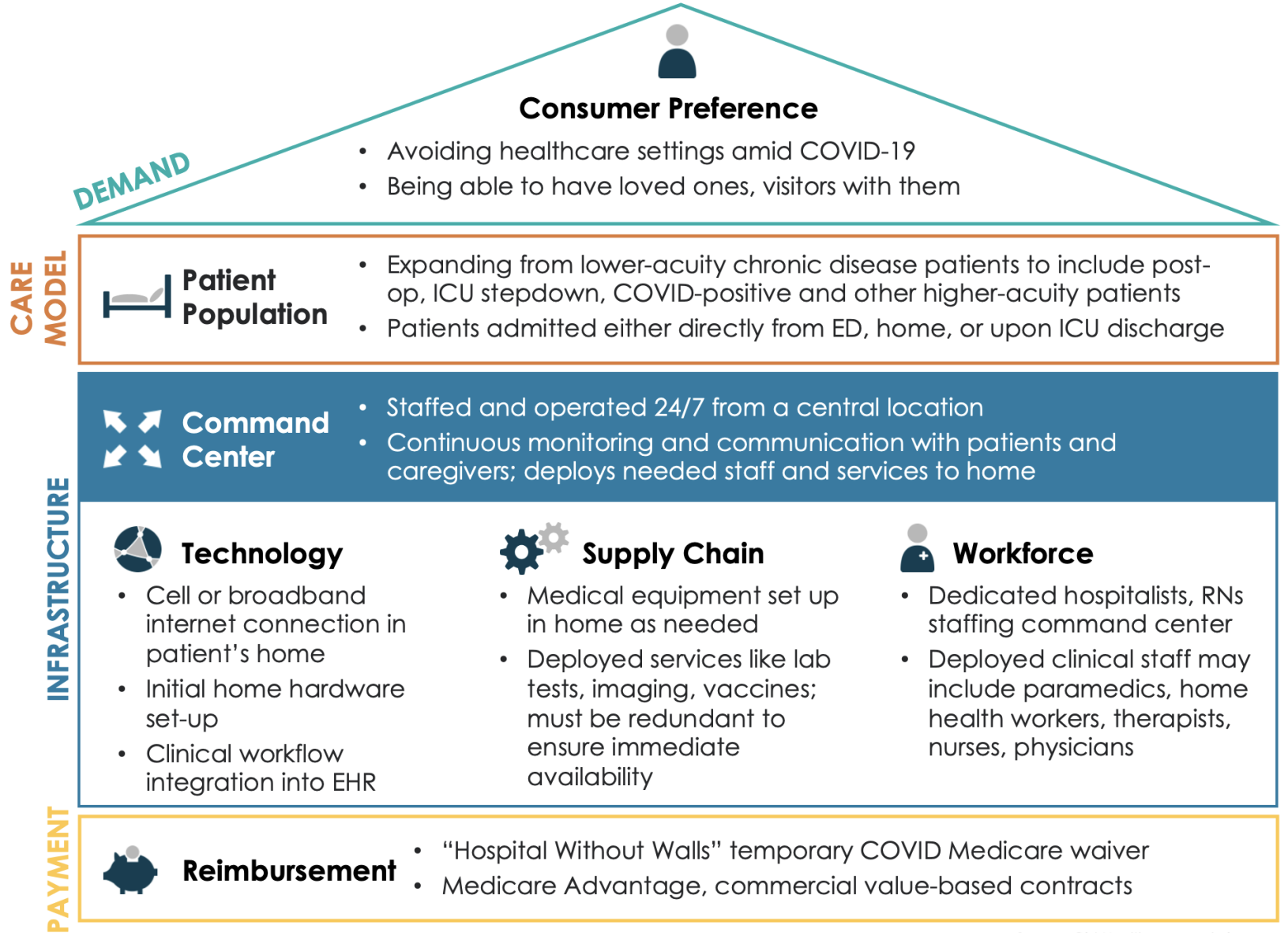
+ Integrated platform
+ GCM

Tele-consulting

+ Homecare support
+ Chatbot

Virtual Hospital = “Homspital” “Virtual ward” “Hospital at Home”

The main components that make up a virtual hospital



Source: Gist Healthcare analysis.

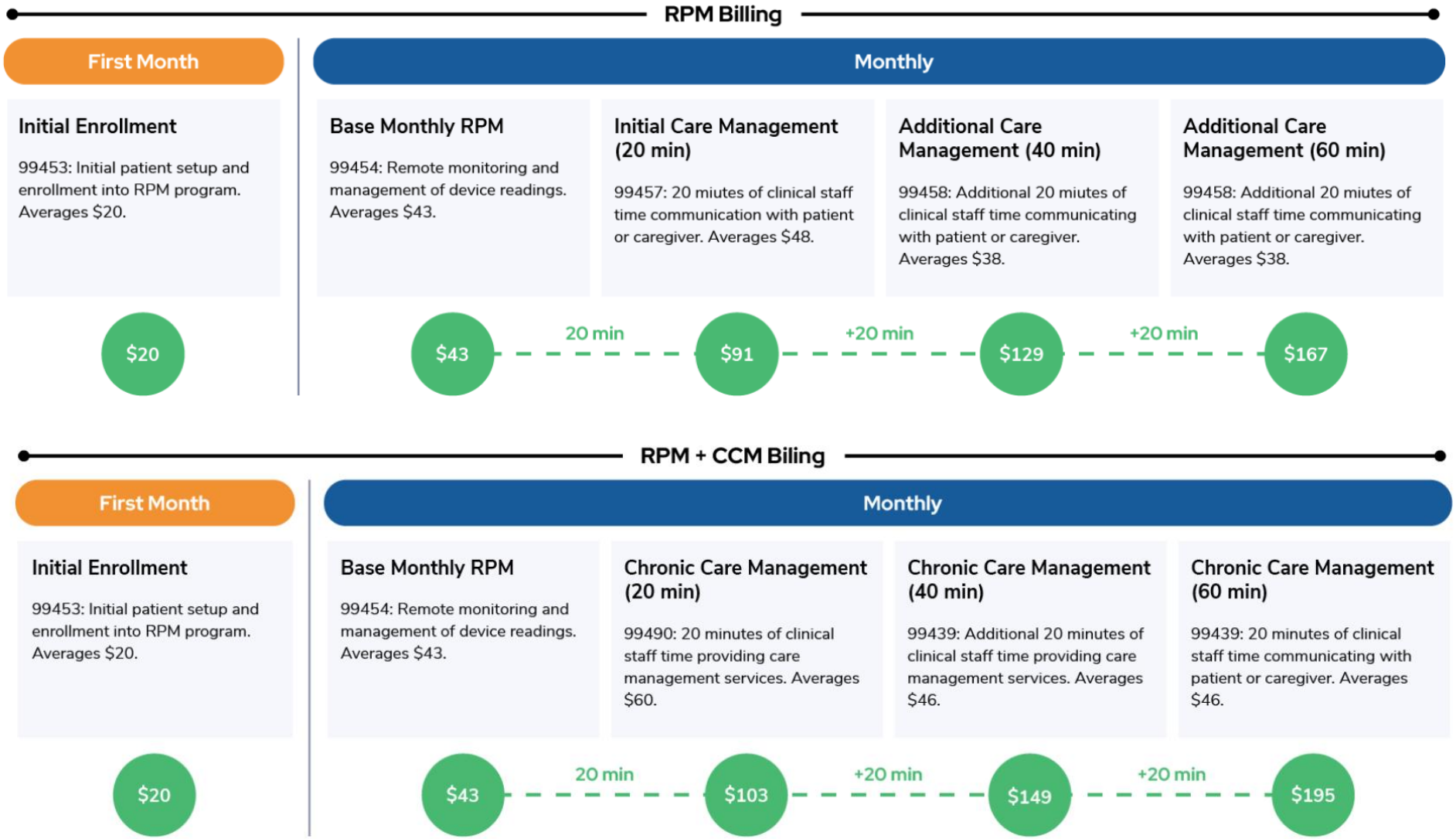
Virtual Hospital = “Homspital” “Virtual ward” “Hospital at Home”

Key components that make up a virtual hospital – overseas cases

Industry and Country	Service Type	Main target diseases	Core Technology	AI application	Visiting Medical Care Connection	Annual use patients	Key Performance Indicators	cost	Reimbursement
HRS (United States)	Remote Monitoring, Virtual Ward	Chronic diseases such as heart failure, COPD, and diabetes	Remote vital monitoring, patient status prediction algorithm	✅ (Prediction of patient condition, risk warning)	✅ (Visiting Nursing Linkage)	Thousands	72% reduction in hospitalization rate and 55% reduction in emergency room visits	About $120~150/mo	✅ (Medicare/Medicaid)
Current Health (United Kingdom)	Remote monitoring, virtual ward	Patients after discharge from the hospital with acute diseases, patients with chronic diseases	Vital Sign Real-Time Monitoring, AI-Powered Disease Exacerbation Prediction	✅ (Real-time AI deterioration prediction)	✅ (Visiting medical care can be linked)	Tens of thousands or more	35% reduction in hospital stays, 92% increase in patient satisfaction	£400~600 per month per hospital	✅ (NHS insurance benefits)
Medically Home (United States)	Virtual inpatient services (in-home wards)	Severe patients such as pneumonia, sepsis, and cancer patients	Virtual Patient Room Platform, Integrated Patient Status Management System	✅ (AI-powered patient management)	✅ (24-hour visiting medical team)	Hundreds of thousands	50% reduction in readmission rate and 30% reduction in medical costs	$300~$400 per day	✅ (U.S. CMS Pilot Project)
Doccla (UK, Sweden)	Hospital-home linked virtual ward platform	Respiratory diseases, heart diseases, and chronic diseases in general	Patient monitoring kits, real-time data analysis	✅ (AI-powered risk alerts)	✅ (Visiting Nursing Team)	Hundreds of thousands	20% improvement in hospital bed utilization rate, reduction of patient safety accidents	About £300~400/month	✅ (NHS coverage)
Babylon Health (United Kingdom)	Digital healthcare, remote monitoring, AI virtual doctor	Chronic diseases such as diabetes and hypertension, mental health	AI chatbot, personalized management platform	✅ (AI chatbot)	❌ (Remote management)	More than 1.2 million	Improved chronic disease management, 35% reduction in hospital visits	Approx. £149/month (personal service)	✅ (Some services are covered by NHS)

Virtual Hospital = “Homspital” “Virtual ward” “Hospital at Home”

The main components that make up a virtual hospital – the reimbursement component

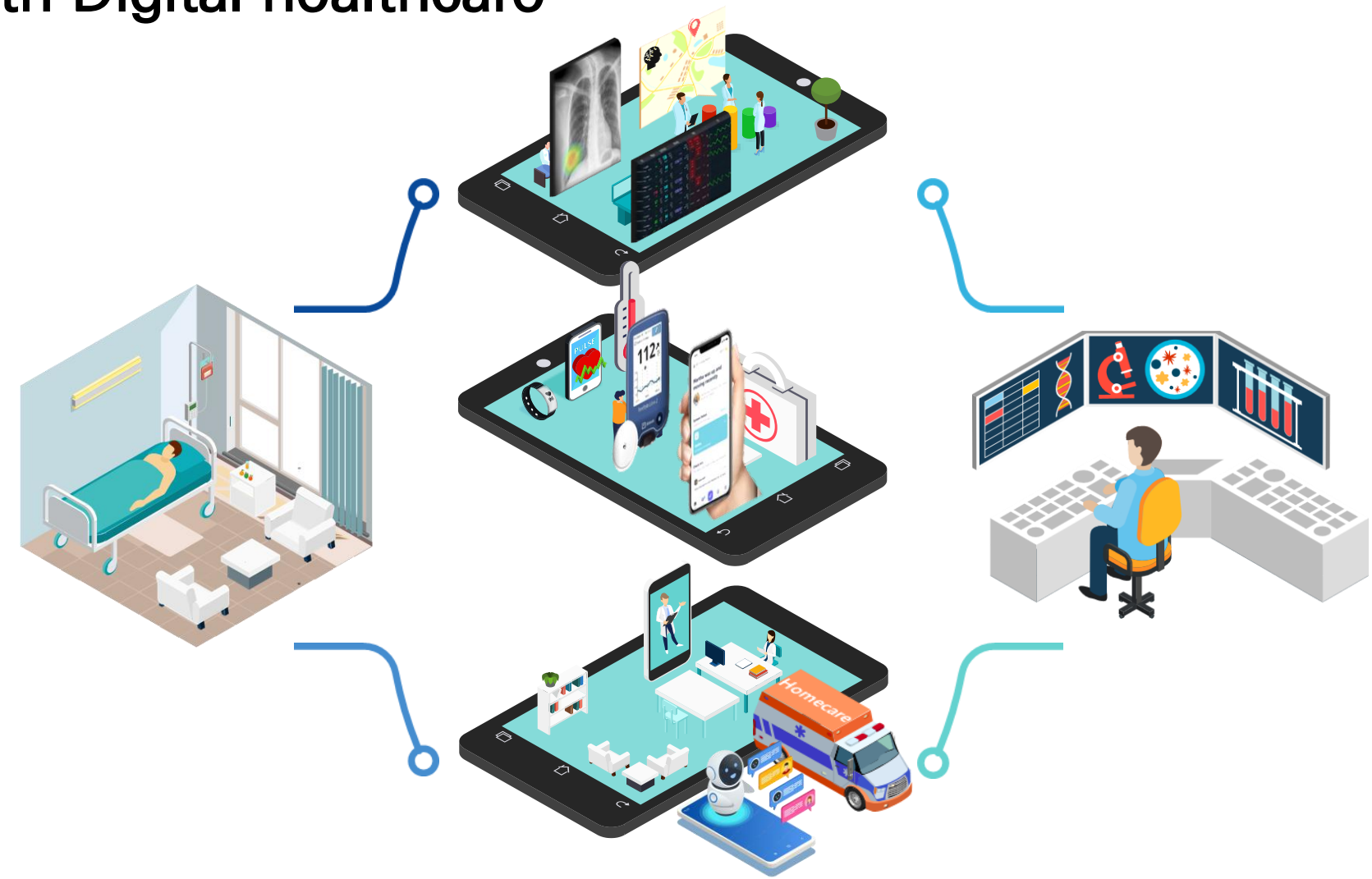


https://www.novanthealth.org/nh/tytohome/

https://www.healthrecoverysolutions.com/blog/2023-remote-therapeutic-monitoring-cpt-codes-cheat-sheet

Community-based Homecare

with Digital healthcare



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