SMART HEALTH HOME:
Technology adoption and social impact

Vladimir Brusic, Professor

Smart Medicine Laboratory

University of Nottingham Ningbo China

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Introduction

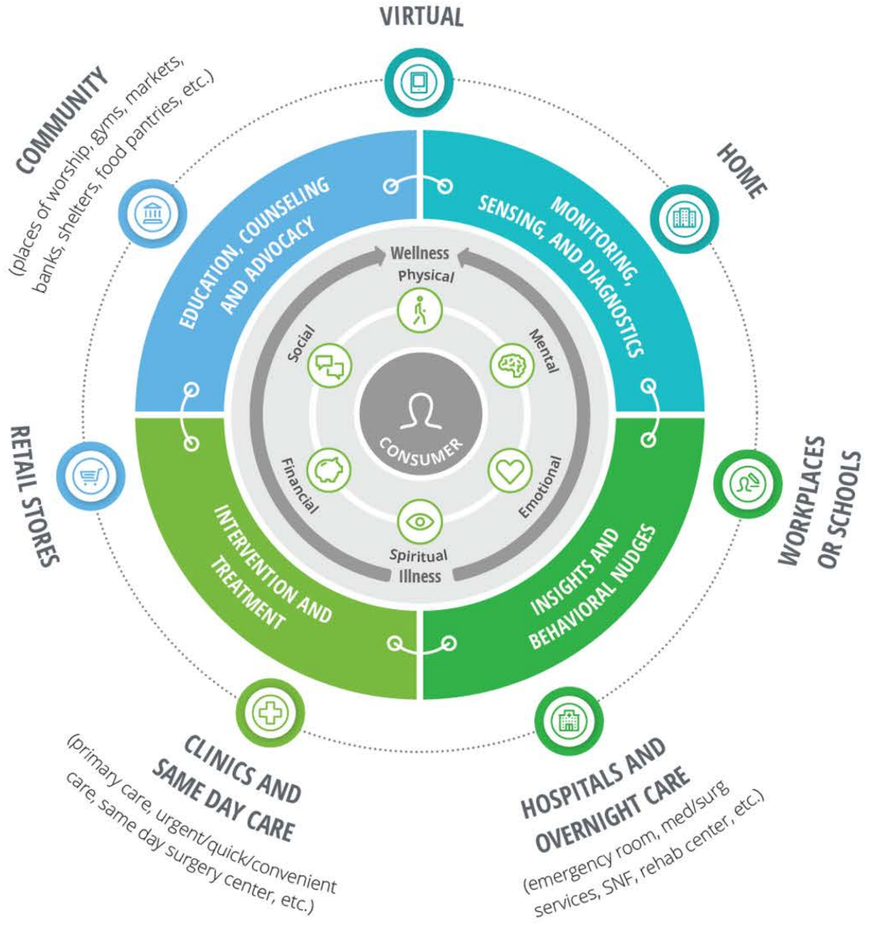
Technology

Legal and regulatory compliance

Socioeconomics

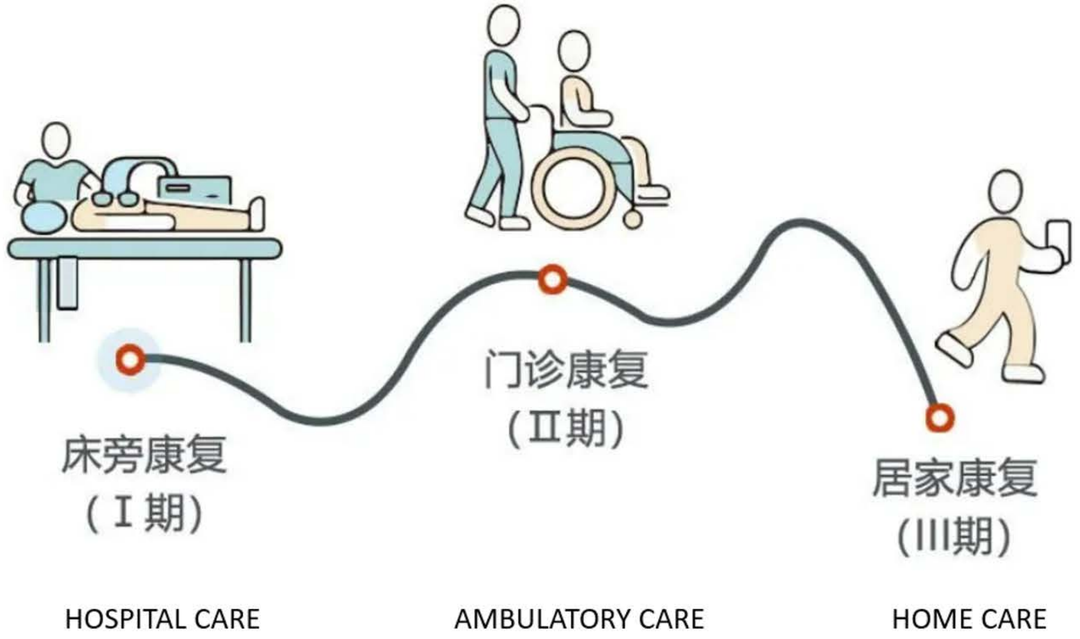
Conclusion

Changing health care delivery models



Source: Deloitte analysis.

Transition to home health care



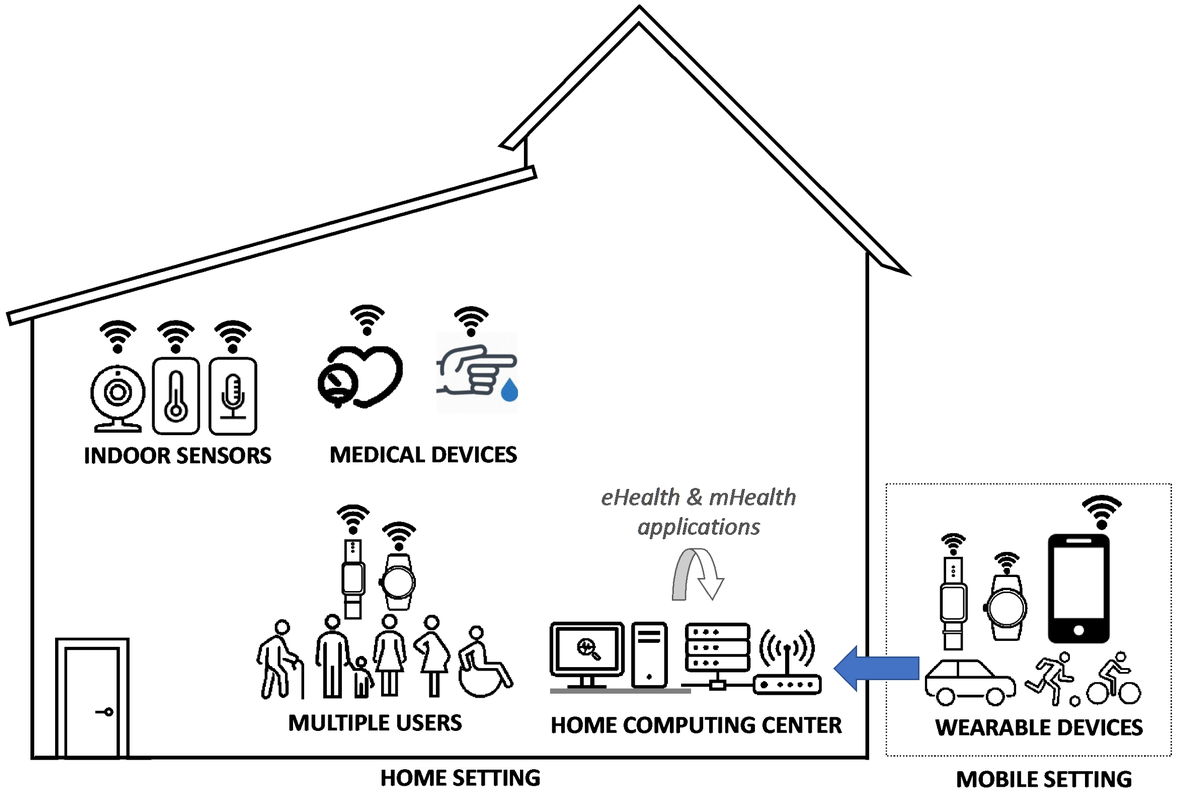
Smart Health Home

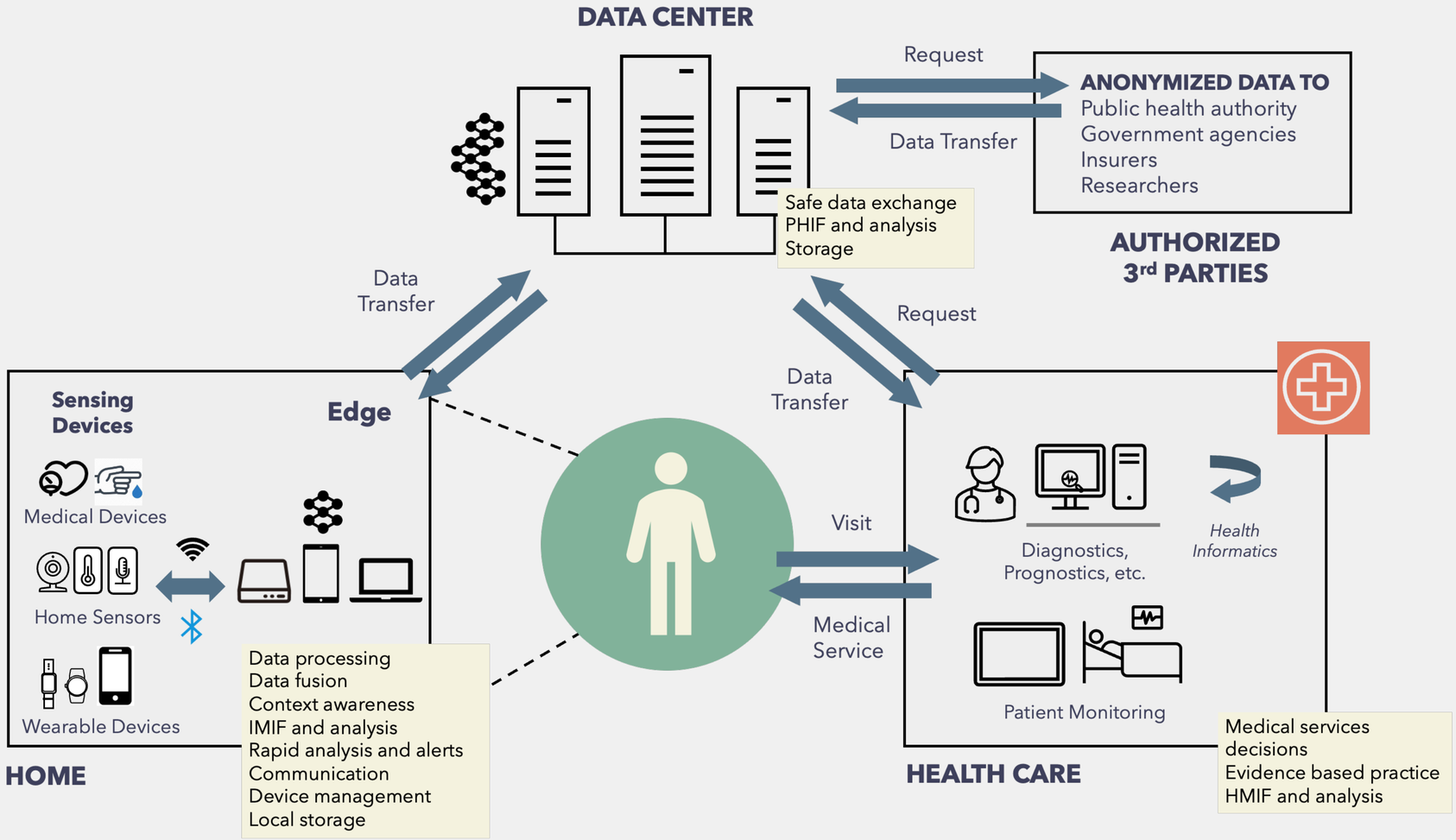
1. Focuses on health monitoring and prevention of disease
2. Expected to provide medical-grade monitoring
3. For use by both patients and medical doctors
4. High level of automation
5. Legal and regulatory compliance

New model, New roles, New challenges

An Ideal SHH:

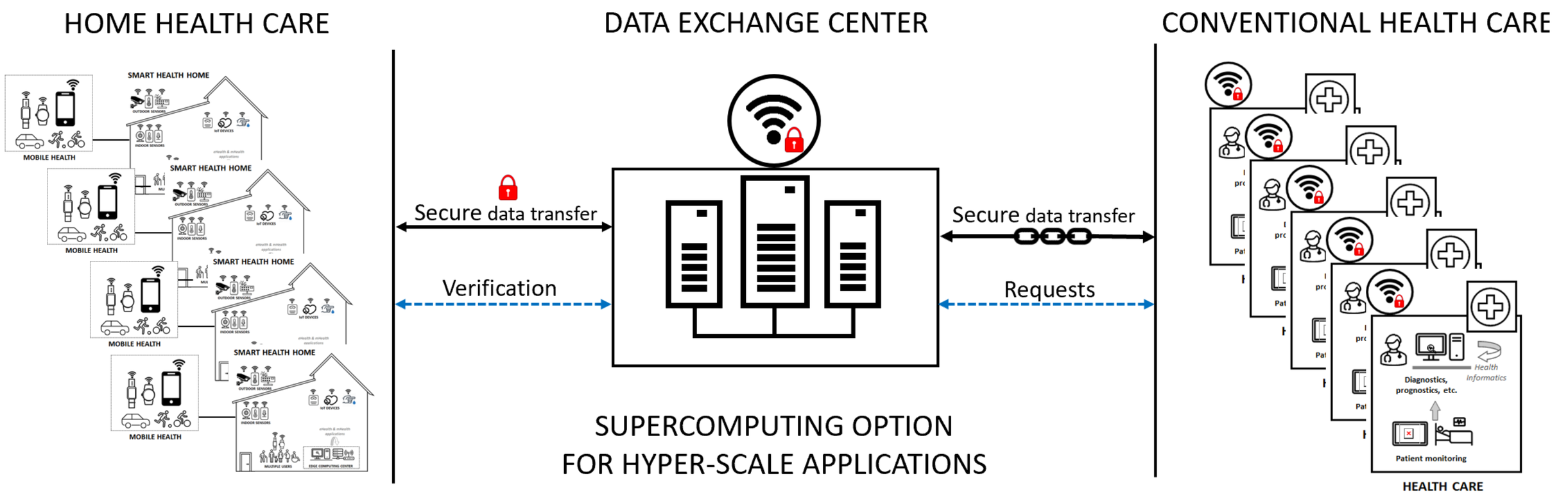
- Effective improve health outcomes
- Compliant with normative requirements
- Useful to all stakeholders





General scheme for Smart Health Home

SCALING UP - SMART HEALTH COMMUNITIES



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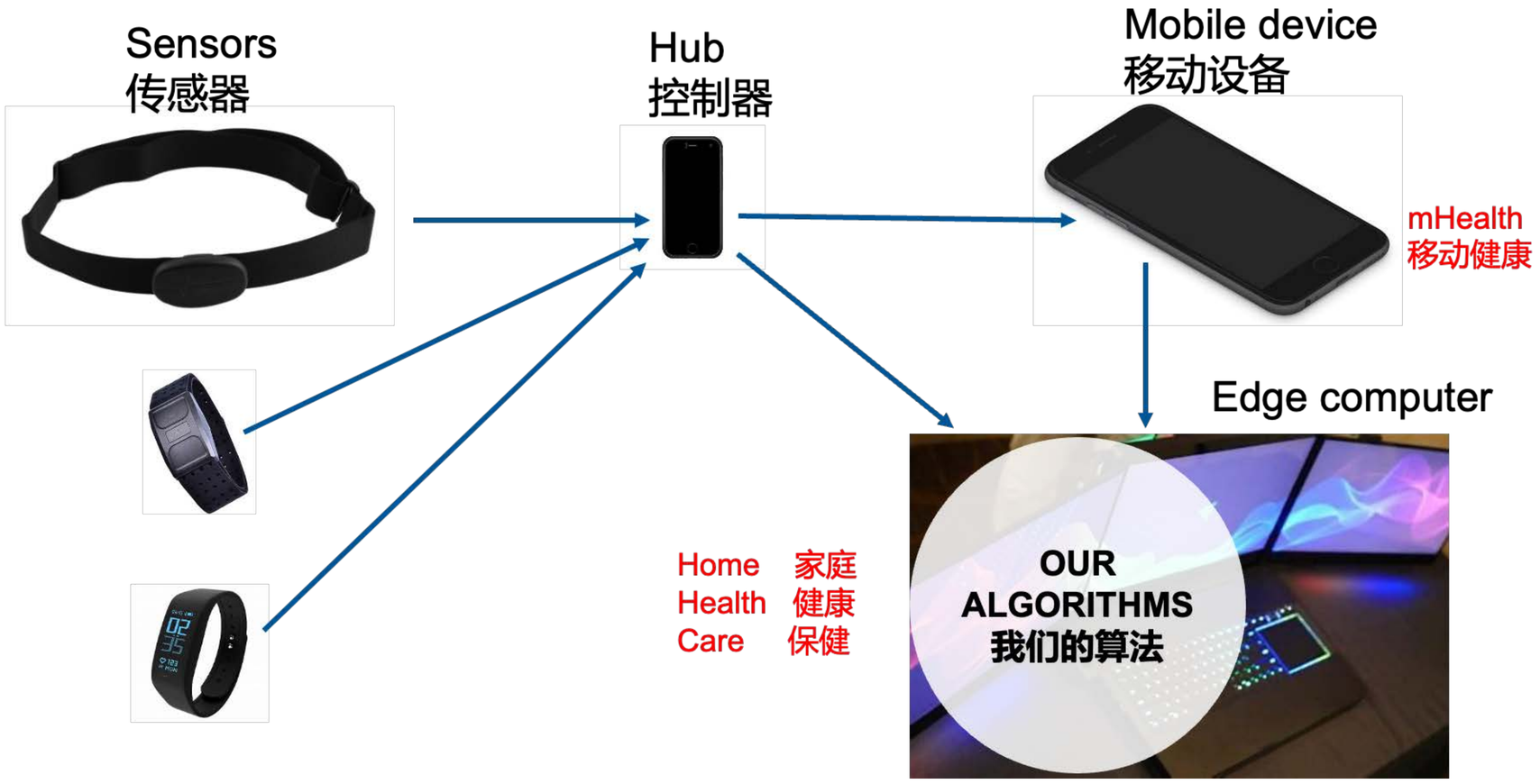


General scheme for Smart Health Home

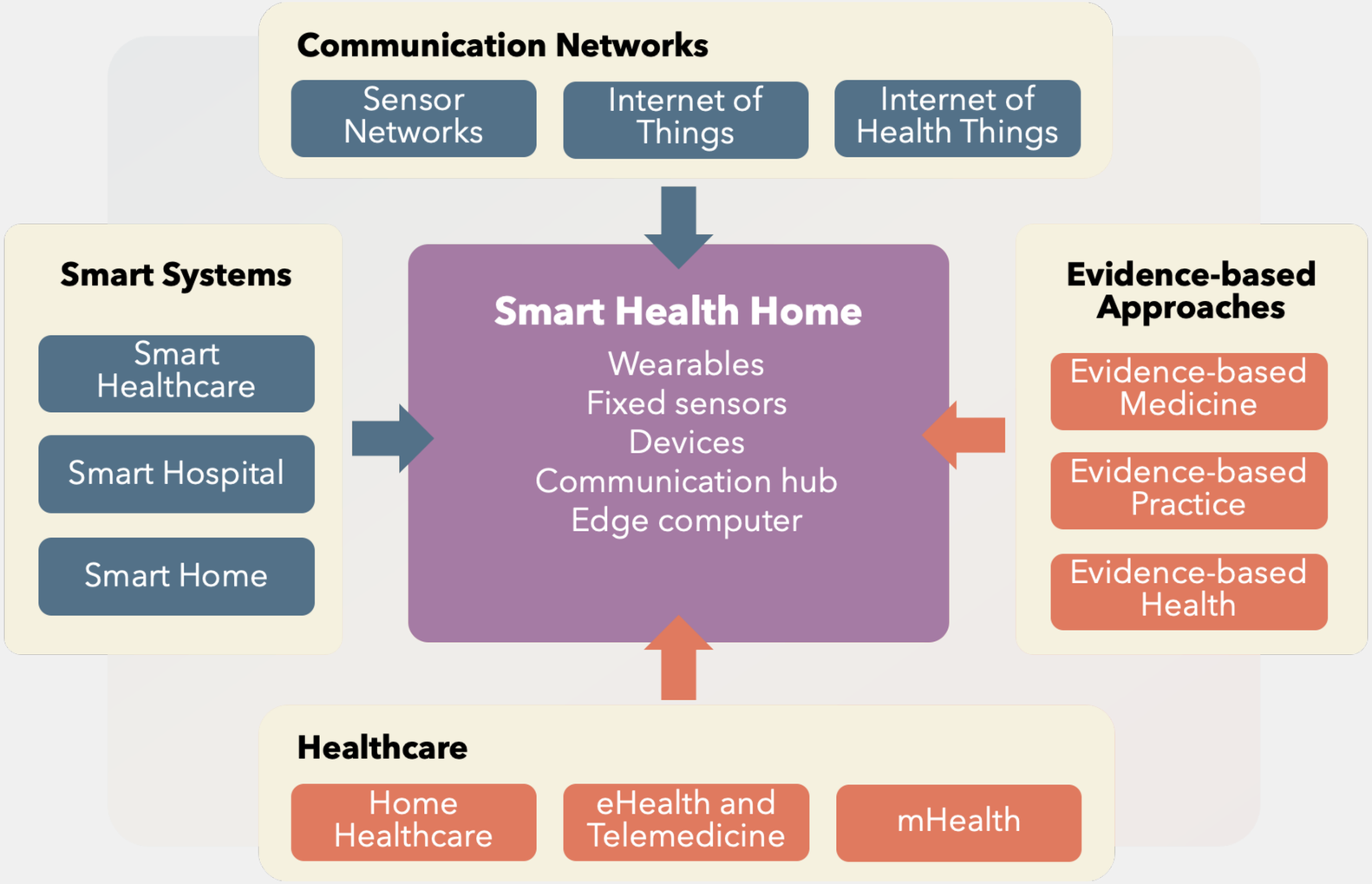
DATA ↑

KNOWLEDGE ↑

ANALYSIS ABILITY ↓

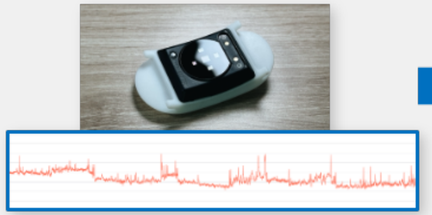
NUMBER OF PHYSICIANS ↓

How to solve this problem?



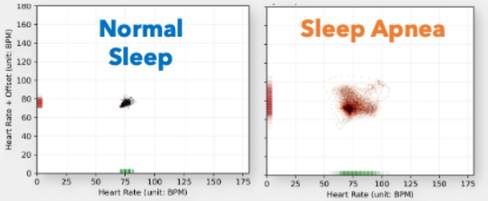
The SHH-centric view of P4 medicine delivery

Prediction, Personalization, Prevention, and Participation



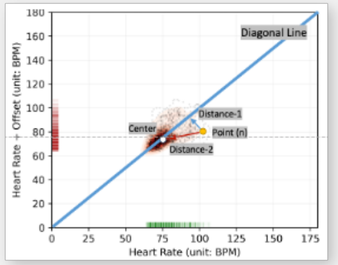
Heart Rate Data Collection

Data Cleaning & Statistics

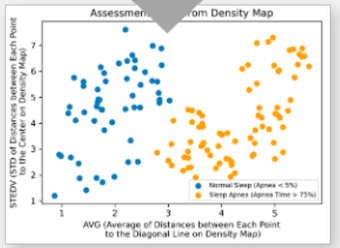


Patterns of normal sleep and sleep apnea present differently on density map

Density Map Analysis



Extract meaningful features from density map by heavy mathematics



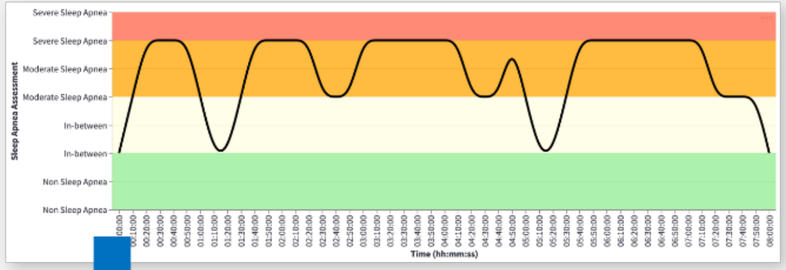
Features that can distinguish healthy/unhealthy sleep will be selected for machine learning

Representative Heart Rate Features

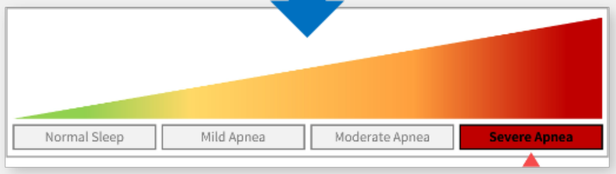
Name of ML Model	Specificity	Sensitivity	Accuracy
MLP	0.97	0.93	0.95
Gradient Boosting	0.96	0.94	0.95
Decision Tree	0.94	0.95	0.94
AdaBoost	0.95	0.93	0.94
SVM	0.96	0.91	0.93
Random Forest	0.96	0.91	0.93
Gaussian Process	0.96	0.91	0.93
KNN	0.96	0.82	0.89
Quadratic Discriminant Analysis	0.85	0.91	0.88
Gaussian NB	0.92	0.82	0.87
Voting	0.96	0.93	0.95

Applied 10 different machine learning algorithms for sleep apnea modelling

Machine Learning Modelling



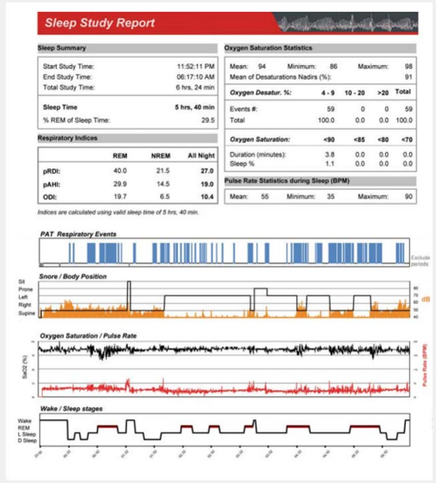
Assess whether and when sleep apnea happens during the sleep

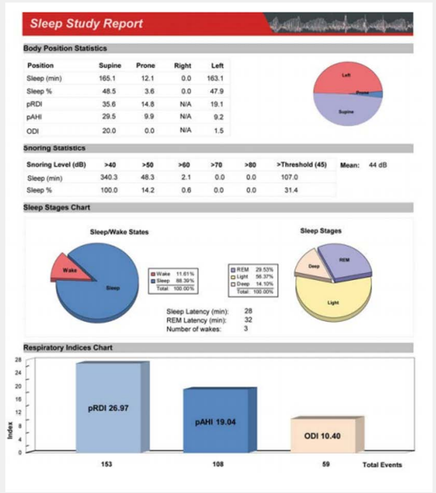


Map the assessments to standard way of representing apnea data in medical practice

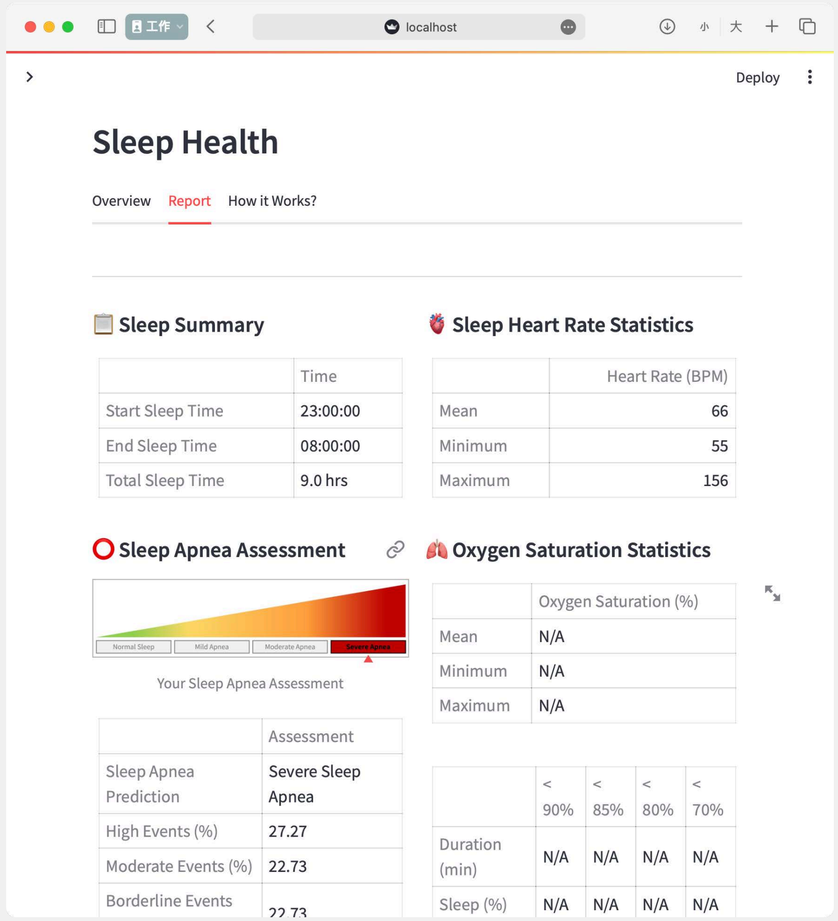
Report

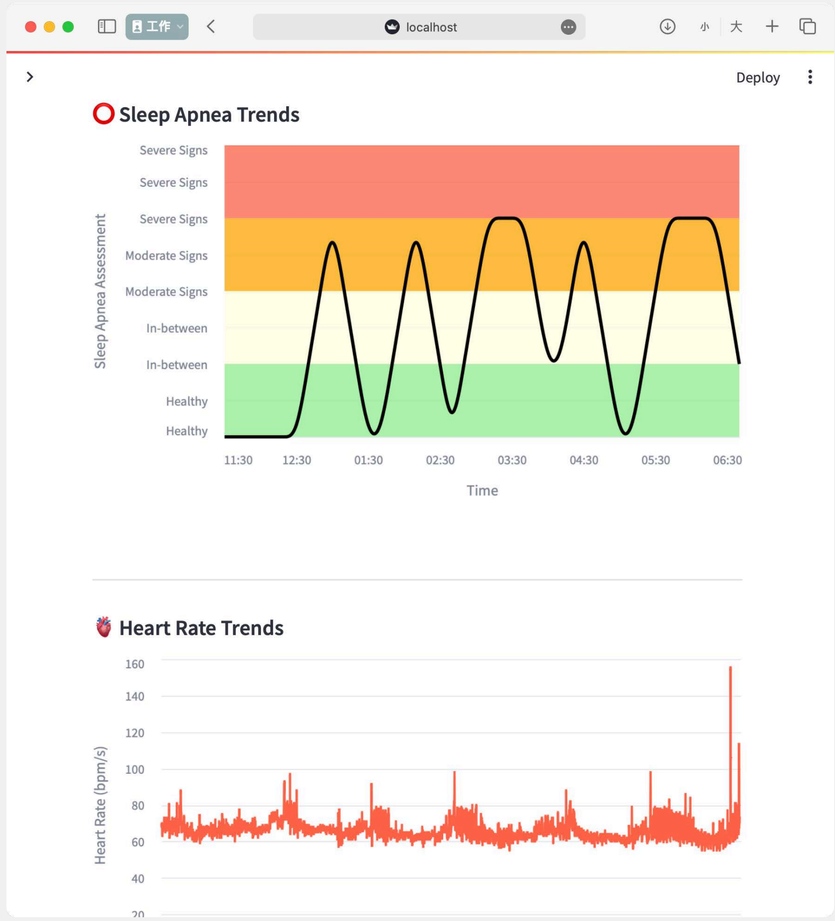
Novel ML algorithms





Sleep Study Report in clinic using PSG





Sleep Health Report by our system (screenshots) using heart rate data from consumer wearables

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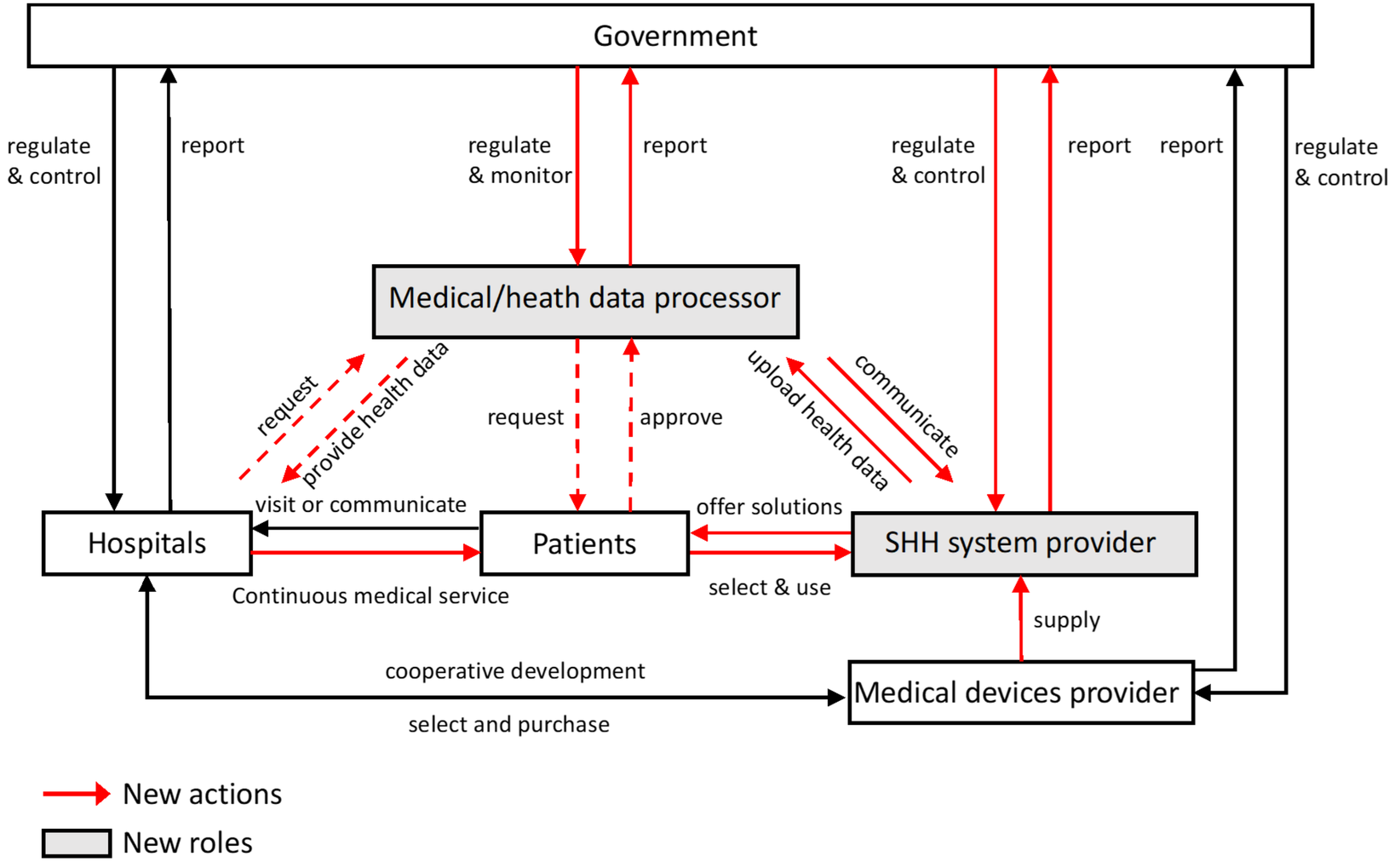
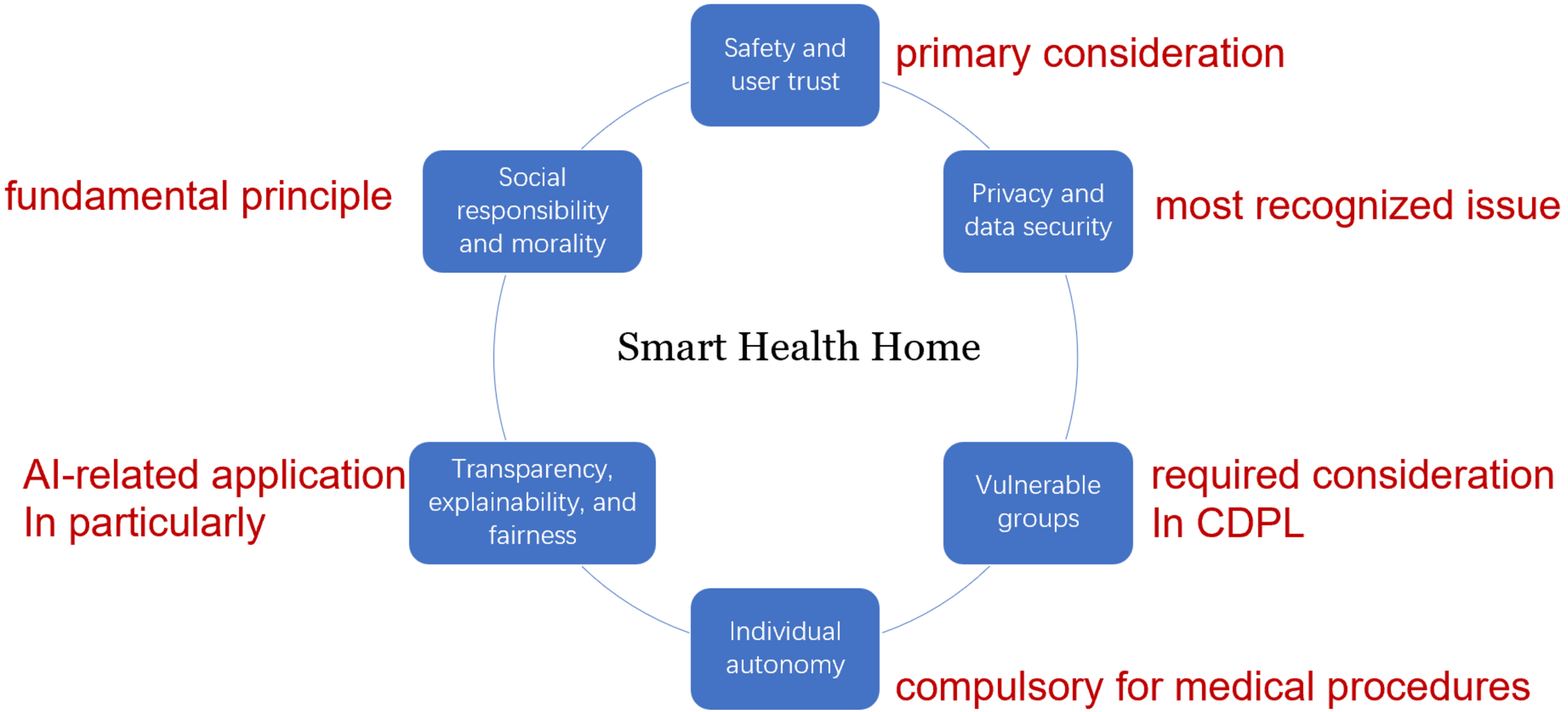
SHH healthcare system stakeholders



SHH Ethical issues



Medical adoption barriers

Home IoT and consumer wearable sensors

- Not certified
- Data not validated or verified

Home medical devices

- Measurements not performed by trained practitioner

Health data sharing

- Not standardized

Clinical validation and efficacy

- Mostly not clear

SHH need to serve as a medical laboratory

Blood work	Patient test results	Normal range	Interpretation of the tests: elevated (↑), low (↓)
Ferritin	10 μg/l	18–350 μg/l	↓
Hemoglobin	72 g/l	138–172 g/l	↓
Red blood cell count	3.35×10^{12}/l	$4.4–5.8 \times 10^{12}$/l	↓
Hematocrit	25.8%	41–50%	↓
Mean corpuscular volume	77 fl	78–102 fl	↓
Mean corpuscular hemoglobin	24.6 pg	27–33 pg	↓
Mean corpuscular hemoglobin concentration	318 g/l	320–360 g/l	↓
Red blood cell distribution width	15.4%	11.7–14.2%	↑

Example of laboratory test results

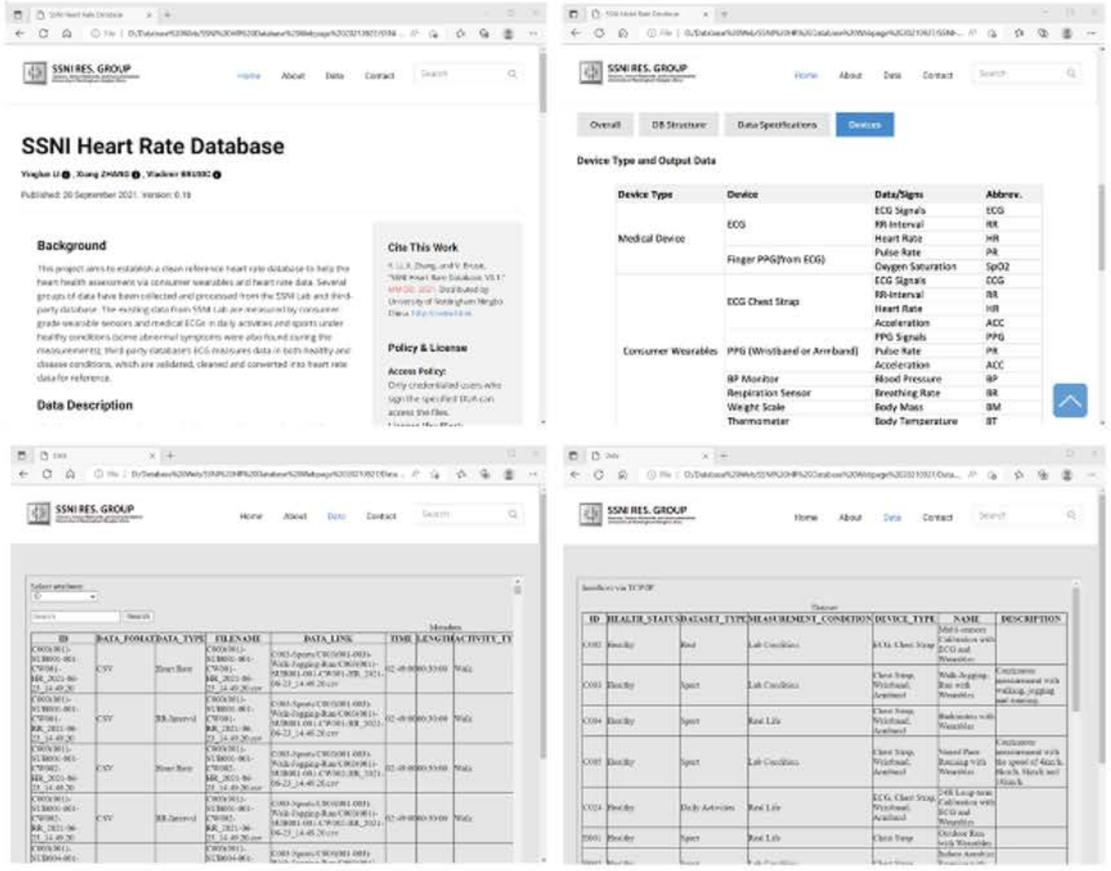
Following designed procedure

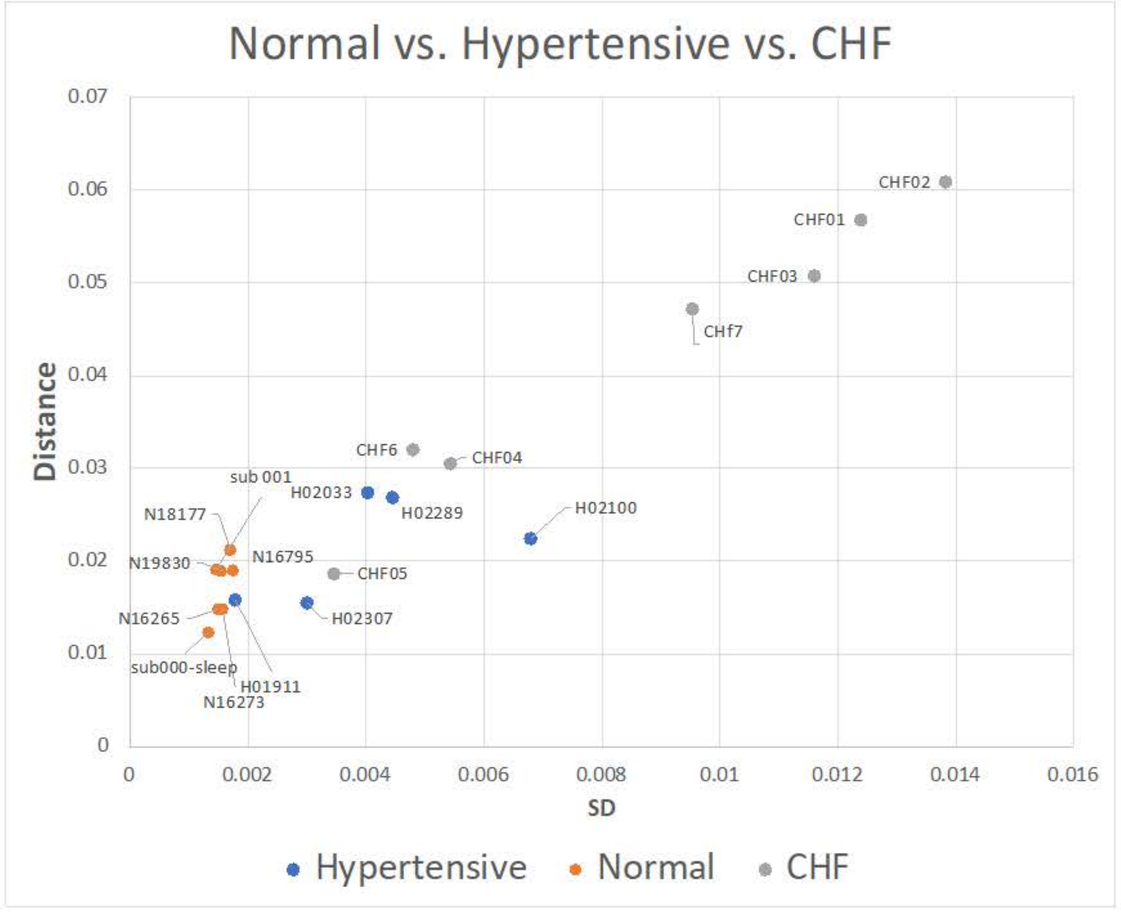
Provide valid data

Provide interpretation

Our calibration experiments

Databases & Heart rate patterns (our IPs)





Patient’s adoption

Privacy - use and governance of personal data

Safety - no harm, improve (or maintain) health

Usability - easy to use

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Smart Health Home must

1. Address the needs of all stakeholders
2. Serve as a medical laboratory
3. Have certification as a medical device/system/software
4. Satisfy the requirements of all stakeholders

Smart Health Home is primarily a

socio-economic and legal issues

and secondarily

medical and technological issues

Thanks to the members of the Smart Medicine Laboratory at the University of Nottingham Ningbo China for work and contributions towards building Smart Health Home!