# Immersive health technologies in cardiology

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@mitcharj



## Health technologies in cardiology



- Problems facing health providers and patients
- Immersive health technologies
- Clinical validation
- Precision and personalisation
- Benefits of an Island locality



## Problems facing modern healthcare



• Costs	
Volume of work	
<ul> <li>Provision of 24 hour staffing</li> </ul>	
<ul> <li>Access to rapid investigations</li> </ul>	E
<ul> <li>Delay (or fear) of implementation of new technologies</li> </ul>	





	Expenditure (£ billions)	Government expenditure (£ billions)	Non-government expenditure (£ billions)	Total expenditure growth rate (%)	Expenditure as % of GDP
2013	171.3	136.0	35.2		9.8%
2014	178.6	142.0	36.6	4.3%	9.7%
2015	185.0	146.9	38.0	3.5%	9.8%
2016	191.7	152.2	39.5	3.6%	9.8%
Source: Office for					

Source: Office for National Statistics (ONS)



#### **EU Healthcare Expenditure Relative To Population Size**

€5,557

Healthcare expenditure per inhabitant in 2015\*

@StatistaCharts Source: Eurostat



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### Health spending as a proportion of GDP



### **Out-patient attendances**





Main Specialty Code	Main Specialty Code Description	All Attendances	Attended first appointment	Attended first tele consultation	Attended subsequent appointment	Attended subsequent tele consultation	Attended but first / subsequent / tele unknown	Percentage of all attendances	Follow-up attendances for each first attendance
All	Total	93,944,301	28,572,548	568,989	62,684,491	1,787,846	330,427	100.0%	2.2
320	Cardiology	2,913,121	1,177,383	9,591	1,664,052	57,370	4,725	3.1%	1.5

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### Immersive technologies



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The application of devices that blur the line between the physical world and digital or simulated world, thereby creating a sense of immersion.

Virtual Reality (VR) is a completely immersive experience in which users are taken from their real-world surroundings and placed virtually into an entirely new digital environment

*"I know its not real but it feels real"* 

Augmented Reality (AR) users can still see the environment around them, but digital content is overlaid into their space



### **Business opportunities**







# Virtual Reality (VR)



Virtual Reality is a completely immersive experience in which users are taken from their real-world surroundings and placed virtually into an entirely new digital environment.

- Early use in games and simulation training
- Pain control / PTSD / phobias
- Resilience / motivational training
- Engagement / teaching





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### Physiological response

Using VR environments to assess physiological response to visual stimulus

Assess heart rate variability, response to medication, virtual stress test

#### **Pain control**

Visual stimulus reduces need for pain relief or sedation

Pacemaker implants

#### **Psychotherapeutics**

#### PTSD

Anxiety / depression Cardiac rehabilitation Heart rate control for procedures (CTCA)

## **Stanford Virtual Heart Project**



#### Education

Lucile Packard Children's Hospital, Stanford VR technology to explain complex congenital heart defects



## **Cardiac rehabilitation**

#### ESC European Society of Cardiology

### **Cardiac rehabilitation**

Exercise with VR component Improved exercise duration Reduced sympathetic tone Greater recovery following intervention



European Journal of Integrative Medicine Volume 9, January 2017, Pages 69-78

#### Research paper

The effect of virtual reality on a home-based cardiac rehabilitation program on body composition, lipid profile and eating patterns: A randomized controlled trial ☆ Agata Solia da Silva Vieira \* 한 유평, Maria Cristina Damas Argel de Melo <sup>6</sup>, Andreia Raquel Santos Noites, Soares Pinho<sup>6</sup>, Jorge Pereira Machado<sup>6</sup>, Joaquím Gabriel, Magaliáleas Mendes <sup>6</sup>

#### Research



Effects of Virtual-Reality-Augmented Cardiopulmonary Rehabilitation Programs for Patients with Cardiovascular Diseases: A Systemic Review

I-Wen Penn<sup>13</sup>, Eric Chuang<sup>1</sup>, Tien-Yow Chuang<sup>4</sup>, Chen-Ya Yang<sup>4</sup> **Neuropsychiatry (London)** (2018) 8(5), 1630–1636



#### Effect of a Virtual Reality–Enhanced Exercise Protocol After Coronary Artery Bypass Grafting

Tien-Yow Chuang, Wen-Hsu Sung, Hwa-Ann Chang, Ray-Yau Wang Physical Therapy . Volume 86 . Number 10 . October 2006

## Sim training / CPD



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### Training

VR environments to assess trainees response to scenarios

Possibility to include physiological measurements

CPD?



# Augmented Reality (AR)



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Augmented Reality users can still see the environment around them, but digital content is overlaid into their space

- Teaching / training
- Medical simulation
- Virtual consultations
- Emergency care avatars



### Holoanatomy



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### Holoanatomy

### Cleveland Clinic Microsoft HoloLens

"Will allow medical students to perform holographic dissections"



## Echopixel



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### Echopixel

Enables a user wearing AR glasses to visualize and manipulate cardiovascular anatomy from standard databases



### AR simulation and consults





### Access to new technologies



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### **CTCA**

CT coronary angiography accepted as standard care for patients with suspected coronary heart disease

Access limited and projected increase X3+ in UK

### Staff and reporting

Limited numbers of cardiologists/radiologists

CT time pressures



## Remote reporting / AI



#### Caristo

Perivascular inflammation using Fat Attenuation Index (FAI)

Strong predictor of cardiovascular risk

Replacement for calcium score and other risk markers?

Non-invasive detection of coronary inflammation using computed tomography and prediction of residual cardiovascular risk (the CRISP CT study): a post-hoc analysis of prospective outcome data

Evangelas K. Okanomou", Mohamed Marwar", Millnd Y. Denar", jernefir Mancia, Akaa Akarh, Erika Hutt Centema, Shenna Thomas, Laona Hendenas, Oristan P. Extainidis, Estilwaine E. Thomas, Bion P. Gaffes, Scatt D. Planma, Akeina S. Antonepodes, Cheeng Shindaria, Nakar: Sahamad, Juhn Tsanfeld, Stafa Nirobaev, Jerman C. Kapeadi, Eckin M. Channon, Stephan Achevalar, Chanadambo Antonaida

http://dx.doi.org/10.1016/S0140-6736(18)31114-0

#### Heartflow

Non-invasive assessment of fractional flow reserve

Guiding coronary intervention

Independence from costly trained staff?

#### 1-Year Outcomes of FFR<sub>ct</sub>-Guided Care in Patients With Suspected Coronary Disease The PLATFORM Study

Panela S. Douglas, Bernard De Bruyne, Giantoca Pontone, Manenk P. Patel, Bjarne L. Norgaard, Robert A. Byrne, Nick Curzen, Ina Prucey, Mathias dustberk: Giller Biodel (Julich Hink, Herney) Water Schuchlere, Martine Glard, Daniele Andreini, Jesper M. Jensen, Martin Hadamitzky, Karen Chiswell, Derek Cyr, Alan Wilk, Furong Wang, Campbell Togers, Mark A. Hattisy and on behalf John Der hLATFORM Investigators

Journal of the American College of Cardiology

Volume 68, Issue 5, August 2016 D0I: 10.1016/j.jacc.2016.05.057







## Wearables and data connectivity



#### Wearables

Vast increase in connected devices IOT 5G networks

#### What to do with the data?



While sleeping Advances in electrodes small and flexible enough to fit in textiles could lead to pillowcases and sheets able to monitor brain waves and sleep patterns. Upon waking Toilets that check urine and stool for disease are being developed. In the future, smart mirrors could measure vital signs with radar, and toothbrushes might analyze saliva.

On the run

Electronics like Fitbits or

attached to the skin can

track exercise, vital signs,

and ultraviolet exposure,

while a "smart bra" might

detect breast cancer.

electric membranes



In the kitchen Smart refrigerators might soon monitor the food stored and record its nutritional information. Food quality and freshness would be tracked, along with dietary habits. Plugged in

Smartphones could analyze patterns that might indicate depression-such as a drop-off in social communication-and alert the user to address potential mental health issues.



In the car Sensors could warn a driver about dangerous pollution levels, high blood alcohol content detected on the breath, and driving that indicates stress and drowsiness.



In your body

Contact lenses may soon check pressure and glucose levels in the eye. Implantable technologies already monitor cardiac activity, nitrogen, and oxygen levels.



#### In the lab

"Electronic noses" could detect volatile organic compounds in the breath or in secretions such as sweat and saliva to find "smellprints" of diseases, including lung and ovarian cancer.

### Feedback and intervention



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The data are interesting

But do they provide value?

Does monitoring make someone feel better or live longer?

Does monitoring reduce health care costs or increase them?

Where to access data?

#### A positive feedback loop

An individual's health risk factors are assessed, then compared with large-scale population data, which can suggest beneficial choices or interventions. Passive monitoring throughout the day is key to constantly improving outcomes.

JASON TREAT, NGM STAFF; KELSEY NOWAKOWSKI ART: CHRISTOPHER DELORENZO SOURCE: SANJIV SAM GAMBHIR, STANFORD UNIVERSITY



### Patient centred records



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# Silo mentality of multiple health data repositories. Focus needs to switch away from the institution / company to the patient



• Potential for device / software integration and testing





Digital Jersey / Health and Social Services DIGITAL STRATEGY FOR HEALTH AND CARE IN JERSEY





## Testing and validation



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# Rapid access to quality-assured, outcome measured clinical research. But how and where?

Providing	Perhaps
Public and professional motivation Enabling healthier populations Law review and change Stimulating new economies 'Walled garden' or 'Shored garden'	The Island as a platform?
	<b>Providing</b> Public and professional motivation Enabling healthier populations Law review and change Stimulating new economies 'Walled garden' or 'Shored garden'







# Local government initiative to promote Jersey as a leading digital health testing and innovation locality

Size - 118.2 sq. km (Area) GDP - £4.11 billion Population - 102,700 Airport - 1.5+ Million People 30+ Destinations World-Class Finance Industry - 13,000 Financial Professionals Investment in Fibre Connectivity, 4G Digitally enabled population Active Tech Community Stable, Independent & Responsive Government Strong Public Finances & a Competitive Tax Base World-Class Data Centres & Extensive Telecoms Network Privacy for R&D





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## The efficacy of a smartphone ECG application for cardiac screening in an unselected island population

Pierre Le Page, Hamish MacLachlan, Lisa Anderson, Lee-Ann Penn, Angela Moss, Andrew R J Mitchell; from the Jersey International Centre for Advanced Studies

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#### Key words

arrhythmia, atrial fibrillation, electrocardiogram, hypertrophic cardiomyopathy, screening

doi: 10.5837/bjc.2015.009 Br J Cardiol 2015;22:31–3 **C**ardiac screening in the community is limited by time, resources and cost. We evaluated the efficacy of a novel smartphone application to provide a rapid electrocardiogram (ECG) screening method on the Island of Jersey, population 98,000.

Members of the general public were invited to attend a free heart screening event, held over three days, in the foyer of Jersey General Hospital. Participants filled out dedicated questionnaires, had their blood pressure checked and an ECG recorded using the AliveCor (CA, USA) device attached to an Apple (CA, USA) iPhone 4 or 5.

There were 989 participants aged 12–99 years evaluated: 954 were screened with the ECG application. There were 54 (5.6%) people noted to have a potential abnormality, including suspected conduction defects, increased voltages or a rhythm abnormality requiring further evaluation with a 12-lead ECG. Of these, 23 (43%) were abnormal with two confirming atrial fibrillation and two showing atrial flutter. Other abnormalities detected included atrial and ventricular



of use, this application could be used as a rapid screening tool for cardiovascular abnormalities in the community.

#### Introduction

Atrial arrhythmias are often asymptomatic and can remain undiagnosed until presentation with stroke or heart failure. Pulse checks can help detect atrial fibrillation (AF) but a recorded electrocardiogram (ECG) remains the gold standard.<sup>1</sup>

We set out to identify the effectiveness of a hand-held, single-lead ECG device to identify arrhythmia and other ECG abnormalities in a large, asymptomatic, unselected Island population.





### Immersion



www.immersion.je



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# Heort for Life screening for heart disease





Population screening DNA database Linked to Jersey Care Record



www.heartscreening.co.uk





# The rapid evolution of digital health technologies has created one of the most exciting times in history to be in the field of medicine

- Immersive health technologies VR / AR
- Patient centred records
- Patient-driven data generation and genomic revolution
- Personalised, precision based medicine

