Patients, Pacemakers, and Implantable Defibrillators: Human Values and Security for Wireless Implantable Medical Devices

Tamara Denning¹, Alan Borning¹, Batya Friedman¹, Brian Gill², Tadayoshi Kohno¹, William H. Maisel³
Implantable Medical Devices

Over 25 million US citizens depend upon them for life critical functions (2001)

Pacemakers, ICDs, Neurostimulators, Drug Pumps

Wireless
Is security necessary?
Unauthorized Wireless Changes: Can Someone Do It?
(Halperin et al. [2008])

Unauthorized wireless communications using custom hardware at short range (centimeters):

- Obtain serial number, patient name, diagnosis
- Turn off therapies
- Induce cardiac fibrillation

(Risk to patients today is low)
Unauthorized Wireless Changes: Would Someone Do It?

March 28, 2008

Hackers Assault Epilepsy Patients via Computer

“RyAnne Fultz, 33, says she suffered her worst epileptic attack in a year when she clicked on the wrong post at a forum run by the nonprofit Epilepsy Foundation.”

January 11, 2008

Polish teen derails tram after hacking train network: Turns city network into Hornby set

“He treated it like any other schoolboy might a giant train set, but it was lucky nobody was killed. Four trams were derailed, and others had to make emergency stops that left passengers hurt.”
Technical Approaches

(Cherukuri et al. [2003], Denning et al. [2008], Gupta et al. [2006], Rasmussen et al. [2009], Schechter [2010])

- Passwords
- Physical Tokens (e.g., key card)
- Fail-Open
- Proximity-Based Authentication
- Physiological Keying
- Criticality-Aware
What is the right solution?
The Human Factor

Real people in their daily lives

http://www.flickr.com/photos/dharmasphere/
http://www.flickr.com/photos/walkingthedeepfield/
Value Sensitive Design
(Friedman et al. [2006], Miller et al. [2007])

Methodology to incorporate human values into design

Values
Affordability
Autonomy
Sustainability
Solitude
Equality
Aesthetics

Methodologies
Value Dams and Flows
Passwords + Body Modifications: Medical Alert Bracelet

Medical alert bracelet with engraved password – using password gives access to IMD
Passwords + Body Modifications: Tattoo

Tattoo with password as scannable 2D barcode – scanning barcode gives access to IMD
Passwords + Body Modifications:
UV-Visible Tattoo

(Schechter [2010])

Tattoo with password as scannable 2D barcode, tattooed with ink that is only visible under a UV light – scanning barcode password gives access to IMD
Passwords + Body Modifications: UV-Visible Tattoo

(Schechter [2010])

Tattoo with password as scannable 2D barcode, tattooed with ink that is only visible under a UV light – scanning barcode password gives access to IMD
Patient Behavior Change: Wristbands

(Denning et al. [2008])

Wristband acts as access control – remove wristband for emergency access

Regular

Emergency and Warning

Patient-Specified Functionality
Passive with Respect to the Patient: Criticality-Aware IMD

(Gupta et al. [2006])

IMD auto-detects emergency situations (GPS location; patient position, e.g. prone; pulse rate) and allows access in emergencies.
Passive with Respect to the Patient: Proximity-Based Authentication

(Cherukuri et al. [2003], Rasmussen et al. [2009])

Equipment carried by medical personnel (in ambulances and emergency rooms) is placed on patient to gain access.
Semi-structured Interview (with mockups)

**QUESTIONS**

- Would you say that you like any of these systems?
- Would you say that you dislike any of these systems?
- If you were given a choice of systems, which system or system would you choose?
- Value questions (e.g., privacy, autonomy, safety, security, health)

**DEMOGRAPHICS**

13 interviews with pacemaker and ICD patients (+3 pilot interviews)

- 8 male, 5 female
- Age 67.9
- 9 pacemakers, 4 ICDs
- ~2nd device
- 7.8 years with IMD
Values that Were Important to Patients

- Security
- Safety
- Privacy
- Aesthetics
- Psychological Welfare
- Convenience
- Cultural and Historical Associations
- Self-Image and Public Persona
- Autonomy and Notification
Values that Were Important to Patients

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“I don’t like the idea of wearing the wristband...I already have a defibrillator. Why do I have to wear something on my hand...to show that I have-, that I have a defibrillator, that there’s something wrong with me. No.”
Values that Were Important to Patients

- Security
- Safety
- Privacy
- Aesthetics
- Psychological Welfare
- Convenience
- Cultural and Historical Associations
- Self-Image and Public Persona
- Autonomy and Notification

“It would make me feel like an invalid...That I had this thing, like the Scarlet Letter or [laughs].”
Values that Were Important to Patients

- Security
- Safety
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- Aesthetics
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“Well, I mean for-, because I’m Jewish it-, I’m not-, a tattoo on the arm to me means a concentration camp. So right away that’s the immediate horror.”
## Mockup Evaluation: Results

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Achieving Coverage: 3 Systems

The Least Disliked: Proximity-Based Authentication

The Most Liked: Emergency and Warning Wristband

Satisfying the Stragglers: UV-Visible Tattoo
Multiple System Options: Revisiting the Idea

- Decreased Usability Means Decreased Safety
- Cost of FDA Approval
- Burden of Training
- Expense of Providing, Acquiring, and Maintaining Equipment
- Mental Stress and Complications of Choice
Questions?