AI Smart Homes: Opportunities for AI and Ethical Challenges

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Disclosures

• InfoSAGE was developed with US government grants from Agency for Healthcare Research and Quality (AHRQ)

• Division of Clinical Informatics received funding from Pfizer for a usability study with InfoSAGE with low literacy populations.

• All commercial products mentioned in this talk are only for illustrative purposes and no endorsement is implied.

• Telemedicine work has been supported by the VA Office of Rural Health and resources and the use of facilities at the VA Caribbean Healthcare system in San Juan, PR. The contents do not represent the views of the U.S. Department of Veterans Affairs or the United States Government”
Healthcare Challenges
Aging Population

• Global population age 60+ is expected to more than triple by 2050

Source: Deloitte 2014 Global health care outlook
Rise of Chronic Diseases

- NCDs are the leading causes of death (63%) in all regions except Africa.
- NCDs projected to cost more than US$30 trillion (48% of global GDP in 2010)
- Respiratory diseases and allergies are a major global problem
Healthcare Provider Shortage

- There will be a shortage of 230,000 physicians in Europe
- The number of caregivers in 36 countries in Africa is inadequate to deliver even the most basic immunization and maternal health services.

Source: Deloitte 2014 Global health care outlook
Highly Fragmented System

Problem: Health data is can’t be easily shared or is shared without consent.

Primary Care Provider
Health Specialist
Emergency Physician
Family Members
Home Health Aids
Community Health Center
Social Media Groups
Homecare Technologies
Mobile App
Rehab Specialist

Formal Care .... Informal Care

Family Caregivers

Division of Clinical Informatics BIDMC
Caring for patients with complex health needs is a challenge for providers around the world.

Integrated Service Delivery: A Leading Age Vision for America’s Aging Population

Technology tools would be used within the integrated service model to help hub providers, older adults and their families:

- Achieve greater information sharing.
- Improve access to services and supports through virtual visits and telemonitoring.
- Engage providers, older adults and families in activities to support wellness and independence.
- Facilitate predictive modeling to improve outcomes and identify best practices.
- Expand access to preventive and chronic disease management tools.

Medication Inserts

Does anyone ever read these pamphlets? Can you ever fold it back to its original fold?
Understanding Medication Labels

How do we optimize how information is organized and presented?

Image Source: https://rxoutreach.org/education-understanding-prescription-medication-labels/
Health Literacy

- HHS defines health literacy as “the degree to which individuals have the capacity to obtain, process, and understand basic health information needed to make appropriate health decisions.

- Only 12% of Americans are at proficient level of health literacy

- Patient comprehension of standard drug information packets is less than 50%.

- Providing literacy-friendly medication summaries to patients can improve comprehension of medication knowledge from 50% to 71%

Sources:
Health Literacy

- Studies have consistently shown that a third of US population is at a basic or below basic level of health literacy
- Patient comprehension of standard drug information packets is less than 50%.
- Providing literacy-friendly medication information can improve comprehension of medication knowledge from 50% to 71%

### Table 1. Descriptions of Health Literacy

<table>
<thead>
<tr>
<th>Health Literacy Level</th>
<th>Task Examples</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proficient</td>
<td>Using a table, calculate an employee’s share of health insurance costs for a year.</td>
<td>12%</td>
</tr>
<tr>
<td>Intermediate</td>
<td>Read instructions on a prescription label, and determine what time a person can take the medication.</td>
<td>53%</td>
</tr>
<tr>
<td>Basic</td>
<td>Read a pamphlet, and give two reasons a person with no symptoms should be tested for a disease.</td>
<td>21%</td>
</tr>
<tr>
<td>Below Basic</td>
<td>Read a set of short instructions, and identify what is permissible to drink before a medical test.</td>
<td>14%</td>
</tr>
</tbody>
</table>

Sources:
Drug-Drug Interactions

**Complexity and volume of potential DDI is difficult to understand specific to each patient**

Source: City-wide electronic health records reveal gender and age biases in administration of known drug–drug interactions, NPJ Digital Medicine, 2019  
[https://www.nature.com/articles/s41746-019-0141-x/figures/1](https://www.nature.com/articles/s41746-019-0141-x/figures/1)
Medication Adherence

Poor Medication adherence is a global problem causing clinical and financial problems

- Adherence to medications for chronic diseases is about 50%
- Non-Adherence can account for up to 50% of treatment failures
- About 125K people die in USA each year because of non-adherence
- 25% of hospital admissions are associated with non-adherence
- Hospital admissions due to non-adherence totals $15.2 Billion
- Nursing home admissions due to non-adherence totals $31.3 billion

Sources:
InfoSAGE Health

http://www.InfoSAGEHealth.org
The most under utilized resource in healthcare is the patient!

Warner Slack, MD
1970

https://www.warnerslack.org
Eldercare Communities

- Aging creates challenges for **elders and their families** for healthcare decision-making, information management, and communication
- **Care Coordination** is exceptionally challenging
- Respecting the **elder’s preferences** and priorities is often lost in transition
InfoSAGE ™
Information Sharing Across Generations

http://www.InfoSAGEHealth.org

- InfoSAGE is a family-based **private social network** for coordinating care that is centered on the elder

- InfoSAGE provides medication management, interaction alerts, educational resources, task management, communication tools for family caregivers

- While designed to support the care of frail elderly, system also works for other illnesses and conditions where families are involved in care support.

**Contact:** Yuri Quintana, Ph.D. Chief, Division of Clinical Informatics, Beth Israel Deaconess Medical Center, Assistant Professor, Harvard Medical School, Email: yquintan@bidmc.Harvard.edu
Co-Design Approach

- Healthcare Partners
  - Hebrew SeniorLife
  - LASELL VILLAGE

- International Sites
  - TAIPEI MEDICAL UNIVERSITY
  - FUNDACIÓN VALLE DEL LILI

- Industry Partners
  - CareAcademy™
  - Connected Home Care
Requirements for Home care e-Solutions

• We need to improve **communication for family caregivers**

• We need to make it easier for patients to **understand medications** (appropriate content and display formats)

• We need to access the latest information from **authoritative sources**.

• We need to make it easier **to update medications lists** from health care provider systems (Apps – FHIR – EMR)

• We need to make it easier **to refill prescriptions**, across providers and countries for travelling patients
What Patients Want

• Need a clear way to communicate medication and care information between patients, home caregivers tailored in terms of literacy level, and technology availability

• Ability to control what is shared and who can access that information

• A central repository of patient friendly information that is up-to-date and validated for usability and health literacy

• Improve tools to track and manage symptoms at home.

• A better way for patients to collect symptoms for remote patient monitoring, have virtual consults, and participate in clinical trials.
Older adult’s use of technology

Usage drops off by age. Form factor is an issue.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Internet Use</th>
<th>Broadband</th>
<th>Smart Phone</th>
<th>Social Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>65-69 (n=531)</td>
<td>74%</td>
<td>65%</td>
<td>29%</td>
<td>54%</td>
</tr>
<tr>
<td>70-74 (n=401)</td>
<td>68%</td>
<td>55%</td>
<td>21%</td>
<td>42%</td>
</tr>
<tr>
<td>75-79 (n=244)</td>
<td>47%</td>
<td>34%</td>
<td>10%</td>
<td>46%</td>
</tr>
<tr>
<td>80+ (n=360)</td>
<td>37%</td>
<td>2%</td>
<td>5%</td>
<td>27%</td>
</tr>
</tbody>
</table>

Pew Research Center April 2014
http://www.InfoSAGEHealth.org

• **Privacy and Control**: Networks are entirely family/elder built, with tiers of access allowing for separation of sensitive health information

• **Task Management**: Shared to-do list, available with user assignment

• **Curated Search**: Aging resources and health information filtered through a custom Google search

• **Medication Management**: Connecting to NIH databases, medications can feature pill images, indications, and scheduling and reminders

• **Drug-drug interactions**: Medication lists are checked against NIH databases for drug-drug interactions
InfoSAGE™ Levels of Access

Keystone Patient  Trusted Proxy  Family Caregivers  Friends

Keystone
Proxy
Caregiver
Participant

Build Network  Edit Medications  View Medications  Add Help List Tasks  Volunteer For Tasks  Communication


http://www.InfoSAGEHealth.org
Time
(months)

0 __________ 10.5 __________ 21

Combined

Keystone 1

Proxy / Caregiver

Keystone 2

Caregiver 2

18 months between date of account creation
Key Observations

- **Community of Care**: Family networks have formed that include spouses, children, grandchildren, and caregivers.

- **Enrollment**: Enrolled families are also geographically spread out, ranging from different neighborhoods within a city to spread out across the country.

- **Feasibility**: Most keystones in this study were able to use InfoSAGE to create an online network, add medications and messages.

InfoSAGE Alexa Voice Interface

https://twitter.com/Yerburu/status/1004644954784849920
Evaluation of InfoSAGE with Rural patients. In collaboration with Dr. Jack Li, Taipei Medical University
Importance of Patient “Equity”

• In the current paradigm one version of patient product information is approved to cover all patients.

• All patients globally, whatever their circumstances, should have access to accurate, up to date and understandable information on their medicines. This is an equity issue.

• Improvements are needed to patient product information to address health literacy needs is an active discussion.

1. Tim Pittman, Duke Health: “Medication nonadherence among patients, particularly those with chronic diseases such as diabetes, has become an expensive problem for the American medical community, with a direct cost of approximately $100 billion annually that may range as high as $300 billion in potentially avoidable spending. Nonadherence in the United States is associated with 125,000 deaths annually and at least 10 percent of hospitalizations.” Online reference here.


3. Internal Pfizer data, available on request.

4. Although some countries have completely eliminated the paper from the pack – eg Japan.

Source and Credits: Pfizer and BIDMC
InfosAGE Low Literacy Mode - Video

Would you like to turn on Color Blind Mode?

Would you like to turn on Large Text View?

START
Key Findings

• All patients found some aspect of the re-designed interface helped their understanding of medications.

• Designs that allow for varying literacy levels are likely to be more appealing to a broader range of users.

• There is a distinct preference to use mobile apps and Internet platforms to access verified medication information.

• Designs that are understandable and well-organized help to prevent mental overload and improve comprehension.

• Navigational elements that can be implemented to appeal to various learning styles.

• Chat functionalities that include human assistance resonate more strongly with users than entirely automated options.

• To cultivate consumer trust and ensure user interfaces are reliable, designing with the end user in mind and doing exhaustive testing cannot be emphasized.
Next Steps

- Improve the medication content using text, graphics, video

Testing Content and Display for Health Comprehension

Propose electronic standard FHIR to be able to update medication information and report symptoms and adverse events to their healthcare providers.
Smart Homes
What is AI Ethics and Human Factors are needed to build trust and safety?
Current Smart Home Health Applications

• **AI integration in home health monitoring** unveils opportunities leveraging IoT and IoB (Rejeb 2023)

• **AI used to analyze extensive health datasets** for diagnoses, treatments, monitoring (Russel 2010, Baker 2023)

• **Internet of Things (IoT)** enables devices to collect, exchange, evaluate health data (Rejeb 2023)

• **Internet of Behavior (IoB)** integrates technology, analytics, behavioral science for insights into behaviors (Gote 2012, Zhao 2023)

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Current Home Health Technologies

- **Wearables**: Fitbits, Apple Watch, monitor physiological data (Al-Rawashdeh 2022, Chan 2021, Anik 2023)
- **Healthcare assistants**: medication reminders, symptom checkers (Dutsinma 2022, Sezgin 2020, Singh 2023)
- **Telemedicine**: consultations, preliminary diagnoses (Pieczynski 2021, Wu 2023, Huang 2022, Li 2020)
- **Ambient assisted living**: monitoring daily activities of elderly (Cath 2018)
- **Automated treatments**: insulin delivery, smart inhalers (Zarsky 2016)
- **Data platforms**: aggregate data from devices/apps, analyze with AI (Mittelstadt 2016)

Citations are available at the end of the presentation.
Marketplace of Solutions

SMART HOME MARKET MAP: 60 COMPANIES MAKING THE HOME MORE INTELLIGENT

GENERAL SMART HOME SOLUTIONS
- Netatmo
- BroadLink
- sevenhugs
- ORVIBO
- LifeSmart
- wigwag
- IOTAS

PLATFOMRS
- seebio
- arrayent
- deako
- LIFX

LIGHTING
- smartfrog
- FENOTEK
- ring

MONITORING & SECURITY
- canary
- HEATWAVE Labs
- ecovent
- Flo

ENERGY & UTILITIES
- rachio
- tado
- radiator
- Labs

HOME ROBOTS
- jibo
- Rokid
- Unibo
- OLLY

SMART LOCKS
- August
- Nuki
- UNIKEY
- Electric Objects
- SONOS

KITCHEN & HOME APPLIANCES
- KUVEE
- innit
- JUCERO
- June
- petnet

MISCELLANEOUS
- nucleus
- analytic
- audio
- phin

HEALTH & WELLNESS
- Sleepace
- Awair
- Eight

AUDIO & MEDIA
- KAMARQ
- INDIE

WI-FI & CYBER SECURITY
- CUJO
- eero
- STARRY
- Luma

ALARM SYSTEMS
- CBINSIGHTS
- CBG
- Dbot
- Leeo

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Marketplace of Solutions

Usability Clinical Grade Devices at Home


Omron’s smartwatch blood pressure monitor cleared by FDA (December 20, 2018)

Garmin Health Partners with ActiGraph to Create Wearables for Clinical Trials (December 17, 2018)

Medical-grade EKG
https://www.alivecor.com
Smart Home Health - Potential Benefits

- Enhanced convenience through remote monitoring and access
- Personalized care and recommendations
- Early diagnosis and prevention of health issues
- Improved medication adherence
- Useful health insights from collected data
Smart Home Health - Privacy and Security Concerns

• Unauthorized access and cyberattacks on health data (Mittelstadt 2016)

• Concerns over data usage, sharing, selling without consent

• Importance of encryption, secure storage, safe data transfers

Are my devices listening to me?

**Key Recommendation:** Transparency in what is being monitored, with who that data is being shared and for what purpose.

Smart Home Health - Reliability and Accuracy Concerns

- Biased data sets will lead to inaccurate predictive models
- Lack of accurate data will lead to inappropriate diagnosis or overlooked issues (Bate 2023)
- Need for rigorous testing and updates to ensure dependability

Addressing Bias and Equity in Data and Systems Design

A Proposed Strategy on Integrating Health Equity and Racial Justice into the Artificial Intelligence Development Lifecycle

Dankwa-Mullan, Scheufele, Matheny, Quintana, Chapman, Jackson, et al.

Smart Home Health - Over-reliance on Technology

- Risk of favoring AI advice over professional medical opinions (Véliz 2020)

- Could delay crucial interventions or obscure full extent of disorders

- Should not replace human judgement and bodily intuition

Smart Home Health - Psychological Effects

- Continuous monitoring could lead to data anxiety (Dignum 2019)

- Preoccupation with health metrics may affect mental health

- AI should aim to reduce, not increase, user anxiety

Smart Home Health- Ethical Considerations

• Lack of transparency in AI health decision-making (Cath 2018)

• Unclear how AI prioritizes advice and treatment options

• Need for explainable and ethical AI reasoning

Smart Home Health - Accessibility and Equity

• Could widen disparities if requires financial means to access (Zarsky 2016)

• Risk of disadvantaging those unable to adopt these technologies

• Importance of inclusive, equitable design

Smart Home Health – Interoperability Issues

- Fragmented landscape of devices, apps, platforms (Rejeb 2023)

- Need for standardized protocols for seamless integration

- Poor interoperability reduces efficacy of smart health solutions

Figure 2. Mapping the Layers of Interoperability to Categories of IT Standards

**Categories of Standards**
- Incorporates all categories of IT and systems to ensure successful implementation, adoption, and use.
  1. Vocabulary and terminology
  2. Content format
  3. Transport
  4. Security
  5. Standards for Services

**Examples of Standards Supporting Each Layer**
- **Process**
  - Audit Trail and Node Authentication (ATNA), Basic Patient Privacy Consents (BPPC)
  - SNOMED, LOINC, RxNorm, ICD-10, HL7, Fast Healthcare Interoperability Resources (FHIR), NHSI, NISO, ASC X12, NIEM (National Information Exchange Model)
- **Semantic**
  - XML, C-CDA, Structured Data, Capture (SDC)
- **Syntactic**
  - TCP/IP, SMTP, S/MIME, HTTPS, X.509, DNS+LDAP
- **Technical**
  - The ability to transfer data between two systems so that it can be read at the machine-level and structured or formatted appropriately without any deeper interpretation.
  - This layer includes all the protocols by which a connection between two systems or devices is established to enable data exchange.

**Process**
The ability for data users (e.g., care providers, clients, software vendors, technology companies) to integrate technology, workflows, and processes in meaningful ways that improve information exchange, outcomes, efficiency, and cost effectiveness.

**Semantic**
The ability of two systems to communicate and exchange information so that the data is read and interpreted the same on both ends.

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Improving Patient Communication with Medication: Opportunities for Generative AI

What is needed to build patient trust and safety for AI-based medication safety?
Example Project: Generative AI for Medication Communication - Potential Benefits

- Improved comprehension through plain, tailored language
- Increased adherence by addressing patient concerns
- Up-to-date explanations adapted to new prescriptions
- On-demand clarification through conversational interaction
Future Directions and Recommendations
Next Generation Home Care Systems

- **Patient-Centric**: Models need to be co-designed with patients and families
- **Communication**: Between healthcare providers and their patients and families
- **Personalization**: Of education and care directives to patient and family
- **Accessibility**: Appropriate technology and form factor for older adults
- **Interoperability**: Agreement on data standards and terminology
- **AI Transparency**: Disclosure of where and how is AI being used?
- **AI Safety**: Need best practices to test AI Safety
Recommendations for Building User Trust

• Provide transparency into AI capabilities and limitations
• Give users control over health data sharing preferences
• Rigorously test for biases and inaccuracies
• Design intuitive, easy-to-use interfaces
• Protect privacy and secure health data
• Seek feedback from diverse users
Conclusions

• Balanced, thoughtful approach needed for ethical AI adoption in home healthcare

• Proactively address concerns and build trust to ensure benefits
Contact

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Selected Yuri Quintana Publications

ALICANTO  http://www.alicantocloud.com


INFOSAGE  https://www.infosagehealth.org


GLOBAL HEALTH INFORMATICS


• https://www.elsevier.com/books/global-health-informatics/marin/978-0-12-804591-6


AI and Smart Homes Citations (Part 1)


AI and Smart Homes Citations (Part 2)

Other Citations (Part 1)

Aging Population:

Rise of Chronic Diseases:
• Percentage of deaths from non-communicable diseases by country, 2013 (DOI: 10.4103/1658-600X.179820 Institute for Health Metrics and Evaluation

Healthcare Provider Shortage:

Challenges Coordinating Care:

Integrated Service Delivery:

Health Literacy:
Other Citations (Part 2)

Drug-Drug Interaction:
- City-wide electronic health records reveal gender and age biases in administration of known drug–drug interactions, NPJ Digital Medicine, 2019 [https://www.nature.com/articles/s41746-019-0141-x/figures/1]

Medication Adherence:

Patient Equity:
- Tim Pittman, Duke Health: “Medication nonadherence among patients, particularly those with chronic diseases such as diabetes, has become an expensive problem for the American medical community, with a direct cost of approximately $100 billion annually that may range as high as $300 billion in potentially avoidable spending. Nonadherence in the United States is associated with 125,000 deaths annually and at least 10 percent of hospitalizations.” Online reference [here].