Healthy Housing for Seniors

Arizona State University Green Apple Project
Healthy Housing for Seniors

- Indoor Environmental Quality
- Housing & Community Design for Active Aging
- Assistive Technologies in the Home
Components of Healthy Housing
Aging & Generational Attributes

Physiological Changes
  Joints, Bones, Muscles
  Respiratory Systems
  Sensory

Cognitive Changes
  Attention, Reactions
  Memory

Emotional Challenges
  Depression
  Hormonal

Cultural Stereotypes
  “The Greenest Generation”
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Overview

1. Indoor Thermal Conditions
   a) Air Temperature
   b) Relative Humidity

2. Indoor Air Quality
   a) Particle Matter
   b) Aldehydes
   c) Acetones
   d) Acetylcs
Components of Thermal Conditions

- Psychological
- People
- Adjustment & Adaptation
- Home
- Temperature • Humidity
- Community/Policy
- ISO & ASHRAE
- Health
- Sleep / Fatigue
- Pain
- Emotional
1. **ASHRAE 55-2010**
   a) Sets parameters to provide adequate and productive thermal conditions
   b) ASHRAE 62

2. **ISO/TS 14415**, addresses conditions of the working ill and disable
   a) Describes the wide range of responses of people with special needs.
Temperature & Comfort

“Thermal comfort, or the lack of it, is well understood to be one of the most significant restrictors to the health and general wellbeing of the older people” (Novieto & Zhang, 2010)

a) Activity levels are affected
b) Behavior
c) Sleeping patterns
d) Emotional responses
Temperature & Health

1. Novieto and Zhang
   a) More prone to thermal related comfort
   b) Relationships between aging and thermal conditions, aging and gradual changes, thermoregulation

2. Van Hoof and Hensen
   a) Older adults require higher ambient temperatures, about 2°C

3. Parsons
   a) Standards do not consider older adults’ requirements
   b) Fitness state decreases, mortality increases on adults 40 and older.
Relationship - Housing & Health

1. Housing/home conditions directly affect health and the ability for independent living for elderly populations

2. Casual links between housing and health include: respiratory conditions, heart disease, cerebrovascular disease, injuries, mental health and some cancers

3. Mortality increases with high temperatures

4. Higher healthcare cost

Image credit: bocahomecareservices.com
Temperature & Adaptive Behavior

1. Age groups often choose different adaptive strategies for comfort
2. Window opening (summer) and clothing adjustment (winter)
3. Comfort temperature range of 80% of the elderly sample was found to be narrower than the younger population. (23.2–27.1° C (73.7-80.78° F), vs 23.0–28.6° C (73.4-83.5° F)
Thermal Differences due to Age

1. PMV index over estimates the comfort vote for elderly populations by 0.5 scale units
2. All things being equal (uniform clo and activity levels) elderly prefer higher ambient temperatures
3. Under constant temperature experiments older adults preferred warmer temperatures than younger adults
4. Moderate temperature drifts are not seen as unacceptable thermal conditions.
IAQ Overview

1. Thresholds
   a) Formaldehyde
   b) Particle Matter

2. IAQ and Health
   a) PM and health Impacts
   b) Indoor formaldehyde
Indoor Air Quality Components

- Physiology • Smoking
- Furnishings • Air Exchange • Sitting
- People
- Health
  - Cancer
  - Respiratory
- Community/Policy
- Air Quality • NAAQS
PM exposure guidelines

1. While WHO and other guidelines govern numerous pollutants, do not specifically quantify PM Exposure Guidelines.

2. Standards for ambient (outdoor) air quality cover a range of sizes and time periods.

3. Ambient Air Quality Standards range from:
   a) 35 mg/m³ for PM2.5 over 24-hrs (US NAAQS)
   b) 50 mg/m³ for PM10 annual average (US NAAQS)
   c) 50 mg/m³ for PM10 over 24-hr (EU)
PM & Health Impacts

1. Numerous studies have quantified the increase risk of health impacts from a 10 mg m\(^{-3}\) increase in PM levels.

2. For PM10, an increase in ambient PM10 of 10 mg m\(^{-3}\) will lead to:
   a) An increase daily mortality of 0.5-0.6% (Samet et al. 2000)
   b) Increased hospitalization for asthma of 1.0-1.5% (Zanobetti et al. 2000)
   c) Increased hospitalization for chronic obstructive pulmonary disease or cardiovascular disease of 0.5-1.1% (Atkinson et al. 2001)
PM sources
# Formaldehyde Thresholds

<table>
<thead>
<tr>
<th>Country</th>
<th>Year Issued</th>
<th>Value</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Australia</td>
<td>1982</td>
<td>0.1 ppm</td>
<td>120 μg m⁻³</td>
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<tr>
<td></td>
<td>2006</td>
<td>0.08 ppm</td>
<td>100 μg m⁻³</td>
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<td>Canada</td>
<td>1987</td>
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<td>120 μg m⁻³</td>
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<td>1987</td>
<td>0.05 ppm</td>
<td>60 μg m⁻³</td>
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<td>0.1 ppm</td>
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<td>0.04 ppm</td>
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<td>China</td>
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<td>S1</td>
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<td>S3</td>
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<td>100 μg m⁻³</td>
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<tr>
<td>Finland</td>
<td>2008</td>
<td>50 μg m⁻³</td>
<td>2 h (proposed)</td>
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<td></td>
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<td>10 μg m⁻³</td>
<td>long-term exposure (proposed)</td>
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<td>120 μg m⁻³</td>
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<td>Germany</td>
<td>1996</td>
<td>0.025 ppm</td>
<td>30 μg m⁻³</td>
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<td>1999</td>
<td>0.081 ppm</td>
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<td></td>
<td></td>
<td>0.3 ppm</td>
<td>370 μg m⁻³</td>
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<td>2003</td>
<td>0.025 ppm</td>
<td>30 μg m⁻³</td>
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<td>Hong Kong</td>
<td>1999</td>
<td>0.081 ppm</td>
<td>100 μg m⁻³</td>
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<td>Japan</td>
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<td>Sweden</td>
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<td>Poland</td>
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<td>100 μg m⁻³</td>
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<td>U.K.</td>
<td>2004</td>
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<tr>
<td>USA (California)</td>
<td>1991</td>
<td>0.05 ppm</td>
<td>120 μg m⁻³</td>
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<td>1990</td>
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<td>0.027 ppm</td>
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<td>2004</td>
<td>0.027 ppm</td>
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<td>2005</td>
<td>0.002 ppm</td>
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<td>1987</td>
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*ALARA = as low as reasonably achievable. *REL = reference exposure limit.
### Table 7. Comparison of Formaldehyde Levels in Indoor Air as Determined in Different International Studies

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<th>Continent/Country</th>
<th>Location</th>
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<th>Continent/Country</th>
<th>Location</th>
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<td>Europe</td>
<td>Germany (1991)</td>
<td>327 residences</td>
<td>55 µg m\textsuperscript{-3}</td>
<td>106 µg m\textsuperscript{-3}</td>
<td>USA (1989)</td>
<td>470 mobile homes</td>
<td>70 ppb</td>
<td>&lt;30 to &gt;300 ppb</td>
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<td>Germany (2008)</td>
<td>586 residences</td>
<td>35.5 µg m\textsuperscript{-3}</td>
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<td>USA (2008)</td>
<td>360 travel trailers</td>
<td>81 ppb</td>
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<td>Germany (2003)</td>
<td>14 office buildings, 1386 measurements</td>
<td>6.9 µg m\textsuperscript{-3}</td>
<td>98 µg m\textsuperscript{-3}</td>
<td>USA (2005)</td>
<td>69 mobile homes</td>
<td>44 ppb</td>
<td>47 ppb</td>
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<td>Germany (2001)</td>
<td>180 Berlin residences</td>
<td>38 µg m\textsuperscript{-3}</td>
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<td>Canada (2003)</td>
<td>151 homes (summary of 5 studies)</td>
<td>29.6 µg m\textsuperscript{-3}</td>
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<td>Germany (1995)</td>
<td>252 residences</td>
<td>12–64 µg m\textsuperscript{-3}</td>
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<td>Canada (2005)</td>
<td>59 residences</td>
<td>9.6–90 µg m\textsuperscript{-3}</td>
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<td>Germany (1993)</td>
<td>190 residences</td>
<td>62 ppb</td>
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<td>Canada (2008)</td>
<td>96 Quebec homes</td>
<td>9.6–90 µg m\textsuperscript{-3}</td>
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<td>Austria (2002)</td>
<td>160 homes</td>
<td>8.8–115 µg m\textsuperscript{-3}</td>
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<td>Latin America</td>
<td>Brazil (2006)</td>
<td>academic institute</td>
<td>&lt;1–82 µg m\textsuperscript{-3}</td>
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<td>Switzerland (1992)</td>
<td>private residences</td>
<td>40 µg m\textsuperscript{-3}</td>
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<td>Mexico (2003)</td>
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<td>7–8 µg m\textsuperscript{-3}</td>
<td>5–9 µg m\textsuperscript{-3}</td>
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<td>Denmark (1987)</td>
<td>14 Danish town halls</td>
<td>40 µg m\textsuperscript{-3}</td>
<td>0–80 µg m\textsuperscript{-3}</td>
<td>Asia</td>
<td>Korea (2008)</td>
<td>52 classrooms summer</td>
<td>70 ppb</td>
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<td>Denmark (1991)</td>
<td>2 new twin apartments</td>
<td>63–384 µg m\textsuperscript{-3}</td>
<td>14–276 µg m\textsuperscript{-3}</td>
<td>Korea (2008)</td>
<td>48 classrooms autumn</td>
<td>40 ppb</td>
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<td>Denmark (1992)</td>
<td>36 apartments</td>
<td>19, 21, 26 µg m\textsuperscript{-3}</td>
<td>11 µg m\textsuperscript{-3}</td>
<td>Korea (2008)</td>
<td>46 classrooms winter</td>
<td>60 ppb</td>
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<td>Finland (2006)</td>
<td>8 buildings</td>
<td>20–43 µg m\textsuperscript{-3}</td>
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<td>Korea (2009)</td>
<td>50 school buildings</td>
<td>209–457 µg m\textsuperscript{-3}</td>
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<td>Finland (2009)</td>
<td>23 office buildings</td>
<td>19, 21, 26 µg m\textsuperscript{-3}</td>
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<td>Korea (2009)</td>
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<td>150 ppb</td>
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<td>Sweden (2004)</td>
<td>27 Uppsala dwellings</td>
<td>2.3 µg m\textsuperscript{-3}</td>
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<td>Japan/Korea (2006)</td>
<td>45 school buildings</td>
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<td>Sweden (2005)</td>
<td>64 bedrooms</td>
<td>23.3–32.5 µg m\textsuperscript{-3}</td>
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<td>Japan (2006)</td>
<td>292 new homes</td>
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<td>Sweden (2001)</td>
<td>181 classrooms</td>
<td>2.3–286.2 µg m\textsuperscript{-3}</td>
<td>67.1 µg m\textsuperscript{-3}</td>
<td>Japan (2006)</td>
<td>60 new homes</td>
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<td>France (2006)</td>
<td>Strasbourg libraries</td>
<td>95 µg m\textsuperscript{-3}</td>
<td>5.4–37.3 µg m\textsuperscript{-3}</td>
<td>Japan (2004)</td>
<td>21 Shinzi residences</td>
<td>71.5 µg m\textsuperscript{-3}</td>
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<td>France (2006)</td>
<td>Strasbourg locations</td>
<td>26.7 µg m\textsuperscript{-3}</td>
<td>34.4 µg m\textsuperscript{-3}</td>
<td>Hong Kong (2002)</td>
<td>37 Nagoya residences</td>
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<td>France (2003)</td>
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<td>41 µg m\textsuperscript{-3}</td>
<td>78 µg m\textsuperscript{-3}</td>
<td>Hong Kong (2006)</td>
<td>16–24 µg m\textsuperscript{-3}</td>
<td>11–24 µg m\textsuperscript{-3}</td>
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<td>France (2003)</td>
<td>61 Paris dwellings</td>
<td>34 µg m\textsuperscript{-3}</td>
<td>78 µg m\textsuperscript{-3}</td>
<td>Hong Kong (2009)</td>
<td>422 offices</td>
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<td>France (2009)</td>
<td>157–187 babies’ homes</td>
<td>19.7–198.7 µg m\textsuperscript{-3}</td>
<td>12.9–9.3 µg m\textsuperscript{-3}</td>
<td>China (2004)</td>
<td>28 hotel ballrooms</td>
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<td>Italy (2009)</td>
<td>20 homes</td>
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<td>China (2007)</td>
<td>public vehicles</td>
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<td>5 office buildings</td>
<td>19.7–198.7 µg m\textsuperscript{-3}</td>
<td>12.9–9.3 µg m\textsuperscript{-3}</td>
<td>Bangladesh (2007)</td>
<td>91 kitchens, impact on children</td>
<td>36.9 µg m\textsuperscript{-3}</td>
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<td>Turkey (2003)</td>
<td>399 kitchens in Ankara</td>
<td>0–2086 µg m\textsuperscript{-3}</td>
<td>79.9 µg m\textsuperscript{-3}</td>
<td>Africa</td>
<td>Egypt (2000)</td>
<td>284 Cairo residences</td>
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<td>25 Ankara dwellings</td>
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<td>67.1 µg m\textsuperscript{-3}</td>
<td>Australia/New Zealand</td>
<td>Australia (2002)</td>
<td>185 homes in Perth</td>
<td>1–166 ppb</td>
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<td>USA (1995)</td>
<td>26 residences</td>
<td>6.5 µg m\textsuperscript{-3}</td>
<td>14.3 µg m\textsuperscript{-3}</td>
<td>Australia (2000)</td>
<td>192 caravans</td>
<td>3–38 µg m\textsuperscript{-3}</td>
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<td>USA (2000)</td>
<td>4 manufactured houses</td>
<td>21–47 ppb</td>
<td>3–44 ppb</td>
<td>Other</td>
<td>aircraft (simulated)</td>
<td>occupied cabin</td>
<td>8–10 ppb</td>
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<td>USA (2006)</td>
<td>7 site-built houses</td>
<td>21–47 ppb</td>
<td>3–44 ppb</td>
<td>submarine (2006)</td>
<td>submerged operation</td>
<td>&lt;10 µg m\textsuperscript{-3}</td>
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</table>
Formaldehyde & Health Impacts

Sources

primary emissions: manufactured wood products, furnishings

secondary emissions: ozone chemistry

Health effects

acute (asthma, Airways irritation)

chronic (cancer)

$O_3 + \text{terpene}$
DESIGN FOR ACTIVE AGING

Sherry Ahrentzen, Elif Tural
Stardust Center for Affordable Homes + the Family
Arizona State University

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Elif.tural@asu.edu
Occasions for research/design cooperation in the design-process cycle.
Active Aging

The desire, ability and opportunity for older adults to integrate physical activity into both structured and unstructured daily routines

Includes physical engagement in economic or socially productive activities
Environmental Press-Competence

Secure Independence
Secure Independence

Safety from Falls & the Unfamiliar
  Secure only doors to high-risk areas
  Secure outdoor areas
  Smooth, well-maintained flooring and paths
  Resilient materials
  Lighting and glare
  Previewing

Home Use & Activity
  Small and familiar tasks
  Cultural and generational ties

Previewing
Secure Independence

Small & familiar tasks
Engagement in Place
Engagement in Place

Heighten interest & curiosity
  Environmental contrast

Minimize distraction, stress
  Auditory privacy
  Visual attention

Social gathering places
  Places near the heart
  Socially stimulating alcoves

Neighborhood Amenities
  Resting areas and furnishings
  Transit accessibility
Engagement in Place

Adapted from: “Common Areas at the Heart.”
Accessibility for the Whole Person

Health
- Cardiovascular
- Musculoskeletal
- Mental/Emotional

Community/Policy
- Fair Housing Act
- Support
- Amenities

Home
- Plan
- Layout
- Materials
- Technology

People
- Physiology
- Sensory
- Cognitive

Accessibility for the Whole Person
Accessibility for the Whole Person

Mobility
- For wheelchairs & scooters
- For walkers and canes

Sensory
- Lighting & glare
- Auditory
- Kinetic & touch

Cognitive
- Multiple cues for orientation
- Clear floor plan
- Control of stimulation
Accessibility for the Whole Person

Flooring material change as a visual cue

Color contrast for cueing
Accessibility for the Whole Person

Minimize squatting

Enhance touch
ELDER HOME HEALTH TECHNOLOGY ASSISTANCE

Kim Shea
College of Nursing and Healthcare Innovation
Arizona State University

Kimberly.shea@asu.edu
Elder Home Health Technology Assistance
Elders in Their Homes

• 65-and-over population (U.S. Department of Health and Human Services' Administration on Aging, 2009)
  – 55 million in 2020
  – 72 million in 2030 (2x 2007)
    • >19 percent of the population
• Chronic diseases with co-morbidity
  – medication
    • complicated
    • compliance issues
  – lifestyle guidance
  – memory assistance
  – physical care
• Chronic physical or mental impairment– (Building Health Systems, RWJ, 2002)
  – 99 million
  – $470 billion annually
Institute of Medicine

• Nonprofit, non-governmental organization founded in 1970, under the congressional charter of the United States National Academy of Sciences.

• Provides unbiased, evidence-based, and authoritative information and advice concerning health and science policy to policy-makers, professionals, leaders in every sector of society, and the public at large

• In 2001 issued aims and design rules for the new century
  – 6 aims
    • Safe, effective, efficient, patient-centered, timely and provides equitable health care
  – 10 rules
    • Patient as source of control, shared knowledge with free flow of information, evidence-based decision making, continuous healing relationships, customization based on patients needs, transparency, anticipation of needs, decrease in waste & cooperation among clinicians.
Assistive Devices

- Environment Interventions
  - Ramps, lowered cabinets, secure flooring
- Assistive Technology
  - Canes, walkers, bath benches
  - Ehealth, Telemedicine, Telehealth
- Monitoring
  - Self
    - Feedback goes to user
    - Wellness or disease management
      - Heart rate monitors, blood pressure, glucose
      - Wearable sensors
    - Motivation for self-care
      - Challenge to make meet needs of consumer
      - Persuasive technology
  - Remote
    - Feedback goes to family or professional
    - Disease exacerbation, independent living, recuperation
      - Fall sensors, movement monitors, risk evaluation
      - Embedded in environment
    - Detect change in status
    - Just-in-time rescue
    - Reassurance
The Smart Home

• The term "smart home" refers to a residence equipped with technology that facilitates monitoring of residents and/or promotes independence and increases residents' quality of life. (Demiris & Hensel, 2008)

• Promoting Independence

http://www.tiresias.org/research/guidelines/smart_home.htm

– Provide an environment that is constantly monitored to ensure the householder is safe (activity monitoring)
– Automate specific tasks that a householder is unable to perform (turning lights on or off)
– Provide a safe and secure environment (alerting the householder of potentially dangerous activities)
– Alert helpers or caregivers should the householder be in difficulties (through linking to a local community alarm scheme)
– Enable and empower the user
– Facilitate in the rehabilitation of householders (by giving prompts that be auditory and/or visual)
What Do Patients Need to Engage in Proactive Self-care? (Horowitz, 2008)

• Enable early diagnosis
  – Ability to collect data that detects a change, assess the meaning of the data, alert patient and make recommendation for making decisions for action

• Enable personal intervention
  – Empowered without calling a healthcare provider

• Improve the quality of communication
  – Better coordinate/communicate among caregiver, service provider, medical provider and peers
Most Common Assistive Devices

• Purpose
  – gathering and transmitting information, reporting and informing (telemonitoring)

• Types
  – Medication Regulation
  – Wandering precautions
    • Managing wandering in the home (monitoring location)
    • Managing exit from the home (alarms)
Smart Home Research

• Systematic Review of research projects on Smart Homes (Demiris & Hensel, 2008)
  – Physiologic monitoring (47%)
  – Functional monitoring and emergency detection (71%)
  – Safety monitoring and assistance (67%)
  – Security monitoring and assistance (19%)
  – Social interaction monitoring and assistance (19%)
  – Cognitive and sensory assistance (43%)

• Need more research on effectiveness of smart homes
Smart Home Complexity

Photo from -http://www.homecontrolplus.net/solutions.html
Labs for Monitoring

Photo from- http://www.topnews.in/your-smart-house-future-will-take-care-you-old-age-2142820

Smart Home Mixes Old with Green and High-tech

Ambient Kitchen

• Lab-based replication of a real kitchen (Newcastle, UK)
• Preparing food and drink was to their sense of autonomy.
• Prompting people in the early stages of dementia through multi-step tasks (Wherton & Monk, 2008)
• The environment integrates data projectors, cameras, RFID tags and readers, object mounted accelerometers, and under-floor pressure sensing using a combination of wired and wireless networks

Photo from: Oliver et al., 2009
Challenges to Home Design

- Ubiquitous, ambient, non-invasive, & ergonomic
- Aesthetics, trends, style, fashion & compatibility with interior design
  - Cost vs. extension of a few months
  - Balancing health needs with home design
- Avoid image of sickness or disability
- Attractive things work better (Norman, D. *Emotional Design*)
- Aesthetics and usability correlate (Tractinsky et al 2000).
- Floor plan
  - Interaction between devices
  - Openness so sensors are not blocked
  - Access to buttons on devices (ex. mirror)
- Connectivity
- Privacy
Conclusion

- Great impetus to keep aging population in their homes
- Smart Home technology is evolving rapidly
- Elders want technology to empower them to make decisions and stay independent
- Research has not focused on effective use
- Many challenges to integration into home
- Opportunities for exploring influence of smart home technology on home design