Design for High- and Low- Resource Settings

Definition of LRS. Low-resource settings are typically characterized by a lack of funds to cover health care costs, on individual or societal basis, which leads to one or all of the following:

- Limited access to medication, equipment, supplies, devices.
- Less-developed infrastructure (electrical power, transportation, controlled environment/buildings)
- Fewer or less-trained personnel
- Limited access to maintenance and parts
- Limited availability of equipment, supplies, & medication.
- Note that there are "Tier-I" and "Tier-II" categories for any given country/setting.

Other characteristics/implications

- Cannot count on electric grid, batteries, or dedicated devices; however, often can piggyback on cell phones.
- Often infrastructure provides the greatest health improvement so Civil Engineers have medical impact.
- Equipment is relatively high-cost compared to personnel, so equipment is less frequently replaced.
- Proper disposal facilities (e.g. incineration) not always available.
- Level of regulation varies by country; enforcement varies by region.
- Generally far from design facilities so design iteration is difficult.
- Patients sometimes far (in terms of travel time) from care facility, so follow-up should be avoided.
- Less education about health in general, but often a lot about specific risks.
- Insurance?

Different diseases

2005 WHO data, from Kortum's Global Health book, p 57. Under-5 deaths, per 1000 U5 population.

	Injuries	Neonatal	Malaria	Measles	Diarrhea
USA+Canada	.2	1.3	~0	~0	~0
Africa	.7	10.4	7.2	2	6.3

Low-resource design and sustainable design are not equivalent. Sustainability applies to both high and low resource settings and means that our activities do not permanently deplete energy or material resources. In developed countries this means decreasing energy consumption, mineral extraction, chemical agricultural practices or monoculturing that deplete soil nutrients.

In underdeveloped countries, sustainability often means avoiding soil depletion and erosion, deforestation (e.g. Haiti vs. DR). We can afford not to destroy forests for fire because we have oil, coal and nuclear, which are built on non-sustainable materials.

We (high-resource communities) can address the deficits in many ways; here are three:
Donations (give money, material, assistance e.g. MSF/DWB)
Increase economic self-sufficiency
Reduce medical system costs ← where bioengineers are needed

Often issue is <u>delivery</u> more than invention.

Bioengineers Without Borders is modeled after Engineers Without Borders, which provides expertise to improve infrastructure. BWB is different because bioengineering is typically done indoors in high-cost facilities. Humans are almost the same world-wide, so technology can be developed at home; the need could be established on location.

Ideally, medical and other technology would be sustainable within each country/region. They could build their own infrastructure: clinics, roads, electrical power; purchase their own supplies, and support their own doctors, wherever they are trained.

We could make designs that are simple to use, more reliable/robust, easy to assemble. Note that are all goals for HRS also, but more critical in LRS. Don't buy more accuracy than you need: Goal can be to help the most lives rather than each life with perfection. E.g. lab in a backpack w/simple devices including microscope that has low resolution but all that is needed is to observe bacteria as dots.

In the short term: it is beneficial to provide donations that support educational programs and allow the regions to establish their own economy and infrastructure. Good example: microloans. Caveat: many loans used for daily life.

COST REDUCTION

1) Pharmaceutical and device industries reduce their costs for purchase in foreign countries. Marginal cost is low and doesn't hurt anyone in this country; otherwise would have no sales overseas. Differential cost model is also used for insurance companies and government-sponsored medication programs (e.g. Canada), and even U.S. hospitals.

2) Design products that require simpler infrastructure: Less space, less training, less refrigeration.

3) Design products that are themselves less expensive: smaller, less material, looser tolerances, designed by low-cost engineers overseas or by college students

PROFITABILITY AND MARKETING

I am not an expert in either so I will provide mostly philosophy

- Reasons that people will give you money
  - Satisfy an actual need
  - Satisfy a perceived or emotional need
  - Alleviate misfortune (medicine?)
  - Trickery / force
  - Allow increased profitability

- Another take on ways to make money
  - Arrange for workers to provide a product or service for customers
  - Reduce worry, specifically to separate the customer from the unpleasantness associated with the production or disposal of goods.
    - Agriculture
    - Mining
    - Low-cost production
    - Trash disposal

- Design for profitability
  - Avoid getting sued
  - Build a better mousetrap
  - Make a disposable product
  - Provide service on product with long service life
  - Make your product appealing

- Marketing targets
  - Customer / patient : improve health, reduce cost
  - Physicians : increase profitability, increase patient throughput, improve outcomes
  - Insurance companies : increase profitability

- Funding device development

  Generally large private funding base for profitable devices. Contrast to large public funding base for lower-profit LRS devices.

  Funding sources for startup companies (vs. new products w/in existing companies)

  Loans

  Stock / interest sales

  Collaborations w/ established partners, large or small

How HRS features affect NEED. Want product that…

- Increases patient throughput and/or decreases cost / patient
- Increases appeal for physicians or patients (e.g. open MRI; laparoscopic surgery is better for patient but not surgeon)
- Provides new capabilities, i.e. draws in new patients or gives advertising benefit
- Combined devices are good; already a lot of equipment in hospital suite.

How HRS affects Specifications:

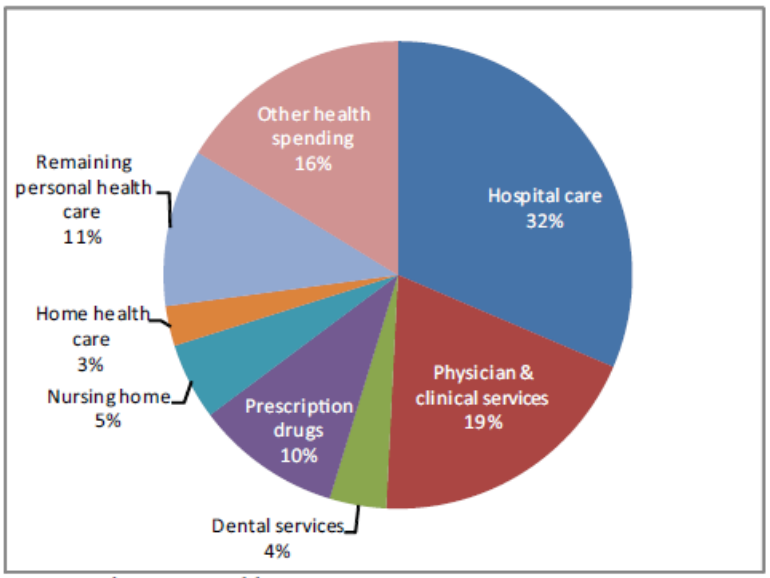
- Can make more precise and less robust, due to presence of maintenance

Design process:

- Regulatory affairs mean it is best to design for new twist on fundamentally proven design.
- Can outsource entire design process, but that doesn't really matter who the end user is.
- Testing implications?

As of 2011, US spends more per capita and as % of GDP than any other country.
http://healthreform.mckinsey.com/insights/latest_thinking/accounting_for_the_cost_of_us_health_care

Exhibit 3. Health Spending by Category, December 2012



Source: Altarum monthly NHE estimates
Note: See Exhibit 5 for complete list of NHE categories

From Altarum Institute, Center for Sustainable Health Spending
http://www.altarum.org/files/imce/CSHS-Spending-Brief_Feb%202013.pdf
Reported as $2.87 trillion annually as of Dec 2012, ~18% of GDP.