Aid Efficacy for Point-of-Use Water Treatment:

Following Interventions from Origin through Implementation to Evaluation

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Motivation & Background

- Drinking water in the developing world has been a major focus of concern and action for decades.
  - International Decade for Clean Drinking Water from 1981-1990
  - International Decade for Action: Water for Life from 2005-2015
  - Millennium Development Goal 7, Target 10
- The problem persists. Technically rigorous technologies may still fail to achieve their public health goals, and well-supported projects are not guaranteed to succeed.

Point-of-Use Water Treatment

- Point-of-use (POU) approaches have emerged as highly-visible and well-supported programs.
  - "... simple, acceptable, low-cost interventions at the household and community level are capable of dramatically reducing the attendant risks of diarrheal disease." WHO 2002[3]
- POU approaches face major concerns about sustainability and scalability.
  - "...widespread promotion of household water treatment is premature given the available evidence." Schmidt & Cairncross 2006[4]
  - "One of the challenges to making informed choices about widespread dissemination of these technologies is the lack of rigorous scientific evidence of sustained use, positive health impact, and water quality improvement over extended periods of use." Sobsey et al. 2008[5]

Evaluation Criteria

- Experts and organizations have begun to develop and apply evaluation criteria to these endeavours.
- "Key features of a sustainable POU technology":[5]
  1. Quantity of water produced
  2. Robustness of treatment process
  3. Ease of use and time required
  4. Cost of treatment
  5. Post-implementation use
- World Bank Development Marketplace selection criteria:[6]
  1. Innovation
  2. Potential for growth
  3. Measurability
  4. Realism
  5. Sustainability

Technology Lock-in

- Technology lock-in explores how random events influence selection during the adoption process.
  - "When two or more increasing-return technologies 'compete' then, for a 'market' of potential adopters, insignificant events may by chance give one of them an initial advantage in adoptions." Arthur 1989[7]
- If decision makers persist with initial intentions, their choices can lead to a non-ideal path for current conditions.
  - "This property of persistence will automatically introduce, sooner or later, some gaps between the intentions under which the structure was selected and the new circumstances and environment." Foray 1997[8]

Research Questions

Many available and emerging technologies undergo rigorous laboratory and field testing but still fail to achieve sustained, long-term use and public health impact. Such failures show that the processes by which technologies are *developed, selected, implemented,* and *evaluated* require further refinement. To improve the efficacy of aid applied toward solving the drinking water problem requires that we first better understand current processes.

- How have existing treatment technologies been taken from initiation through implementation to evaluation?
- To what extent is *"user control"* – i.e., control over use, repair, and replacement of a technology – espoused by organizations?
- What factors affect decision making at each step of the process? Specifically, are espoused concepts of "user-control" and "community empowerment" truly well considered throughout the process?

Table 1. INFLUENCING FACTORS

STAKEHOLDERS	FINANCIAL	SOCIAL and INSTITUTIONAL	GEOGRAPHIC	TECHNICAL	ENVIRONMENTAL
User - Individual - Household - Community	Willingness to pay Ability to pay Maintenance costs	Appropriateness to local culture, norms & behaviors	Proximity to supply chain Access to replacement parts or units	Ability to understand, use and repair technology	Appropriateness to environmental conditions
Parent Company or Organization	Research and development costs Cost of raw materials, supplies, tooling Production scale-up	Existing relationships; organizational policies Networking	Proximity to potential partners Access to implementation sites and organizations	Existing expertise & experience Available equipment, machinery, etc.	Waste & chemicals from production process Waste & chemicals produced during use of technology
Implementing Organization or Agency	Purchasing cost Shipping & distribution cost	Existing relationships; organizational policies Networking	Proximity to potential partners Proximity & access to implementation sites	Existing expertise & experience Available equipment & supplies	Means of disposal of broken parts or units

Methods: Follow each technology from origin through implementation to evaluation. Focus on personal and organizational connections, decision processes, and user control.

Case Study Technologies

Hydraid® BioSand Water Filter

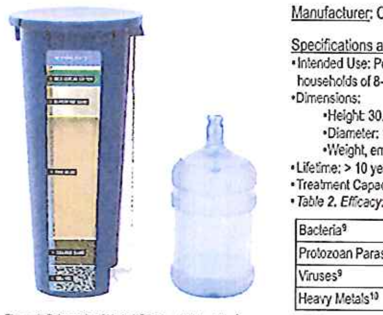

Figure 1. Schematic of Hydraid® BioSand Water Filter[9]

Manufacturer: Cascade Engineering

Specifications and Features[9]
- Intended Use: Point-of-use treatment for households of 8-10 people
- Dimensions:
  - Height: 30.5 inches
  - Diameter: 16.5 inches
  - Weight, empty/full: 8/135 pounds
- Lifetime: > 10 years
- Treatment Capacity: 0.8 liters/minute
- *Table 2. Efficacy:*

	Removal
Bacteria[9]	90-99.9%
Protozoan Parasites[9]	99.999%
Viruses[9]	80-99.9%
Heavy Metals[10]	No removal

Field Testing of BioSand Technology:
- Public Health Impact: 47% reduction in diarrhea compared to control after 6 month intervention[11]
- E. coli Removal: ~83% reduction in concentrations in household water[11]
- Post-implementation use: >85% compliance[12,13]

LifeStraw®

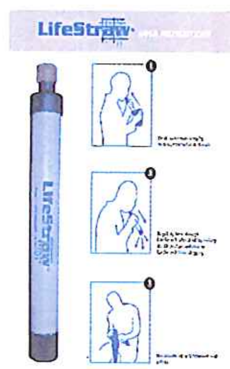

Figure 2. LifeStraw® User Instructions[14]

Manufacturer: Vestergaard Frandsen

Specifications and Features
- Intended use: Point-of-use treatment for individual users
- Dimensions[15]:
  - Length: 12 inches
  - Diameter: 1 inch
  - Weight, dry/wet: 0.31/0.35 pounds
- Lifetime: 1 year, 1000L
- Treatment capacity: 0.2 liters/minute[16]
- *Table 3. Efficacy:*

	Removal
Bacteria[17]	99.9999%
Protozoan Parasites[17]	99.9%
Viruses[18]	95.6-98.2%
Heavy Metals[17]	No removal

Field Testing of LifeStraw[6,19]:
- Public Health Impact: 25% reduction in diarrhea compared to control during 5 month intervention
- Thermotolerant Coliform Removal: 100% removal in filtered water
- Post-implementation use, after 5 months:
  - Preceding week: 34%
  - Preceding month: 41%
  - Ceased use: 37%

Influencing Factors: Initial Findings

Hydraid® BioSand Water Filter [10, 11, 20-26]

KEY: DATE: Event [Location] Other Information — *Note: symbols indicate influencing factors; see legend below*

- Concrete — *Local production*
- 1990: BioSand Water Filter — David Manz, Calgary
- 1993: Pilot Project [Nicaragua] — Division of International Development, University of Calgary
- 1999-2001: Implementation [Ethiopia] — Samaritan's Purse, Calgary
- 2002: Rotary Pilot Project [Dominican Republic] — Jim Bodenner (Rotary District 6290), Bob Hildreth
- 2004: CDC Analysis [Dominican Republic]
- 2005: Randomized, Controlled Trial [Dominican Republic] Funding: Rotary
- Plastic — *International Distribution*
- 2006: License to International Aid [Michigan] — Jim Bodenner, Dir. of Water Initiatives
- 2008: Hydraid® Partnership [Michigan] International Aid
- Aug 2009: International Aid ceases Hydraid® program
- Dec 2009: License to Cascade Engineering
- Jan 2010: Triple Quest [Michigan] Cascade Engineering & the Windquest Group; Jim Bodenner, Rotary District 6290
- 2010: Comprehensive Implementation Program [Dominican Republic] Funding: Rotary International, USAID

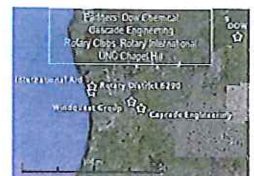

Figure 3. Locations of Hydraid® Partners in Michigan

Influencing Factors:
- Geographic proximity of potential partners
- Connections and access to implementation sites
- Existing relationships and networking
- Passionate individuals
- Existing expertise, available equipment
- User control, including:
  - Local production and sales (e.g., Concrete)
  - Mass production and distribution (e.g., Plastic)
  - No moving parts
  - Training workshops and online resources for implementation and use

LifeStraw® [16, 18, 27-30]

- 1994: CDC testing of PVC pipe filters — Dr. Ernesto Ruiz-Tiben, Carter Center
- 1993: Mesh filters — VestergaardFrandsen Supplier to Carter Center
- LifeStraw® Portable Water Filter VestergaardFrandsen
- 2005-2006: INDEX: International Design Award; Well-Tech: Innovation Technology Award
- 2007: Randomized, Controlled Trial [Ethiopia]
- 2008: Saatchi & Saatchi Award For World Changing Ideas

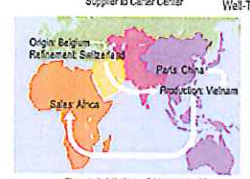

Figure 4. LifeStraw® Worldwide[30]

Influencing Factors:
- Passionate individuals
- Existing expertise, available equipment
- User control, including:
  - No moving or replacement parts
  - Training workshops on implementation and use
  - Pictorial and written instructions on packaging
- Availability and focus of donor funds

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