DEPARTMENT OF

BIOMEDICAL ENGINEERING

MARQUETTE UNIVERSITY AND MEDICAL COLLEGE OF WISCONSIN

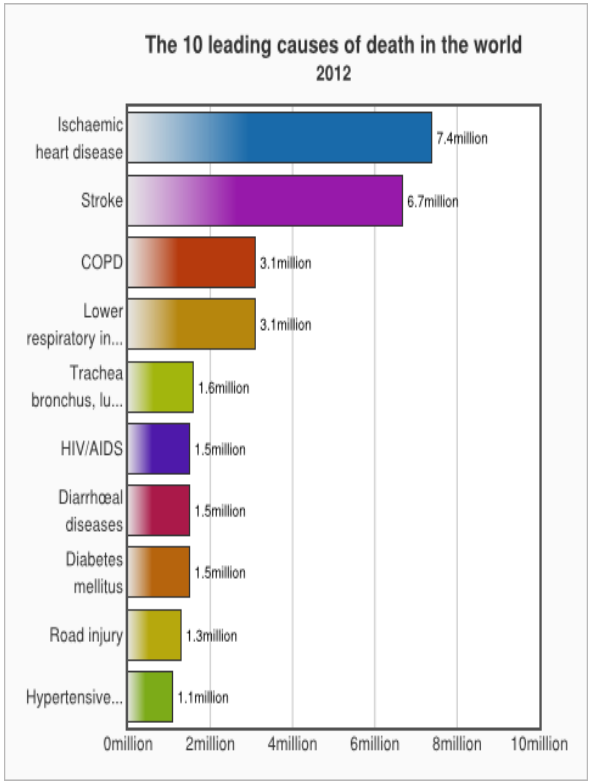
MEDICAL COLLEGE OF WISCONSIN

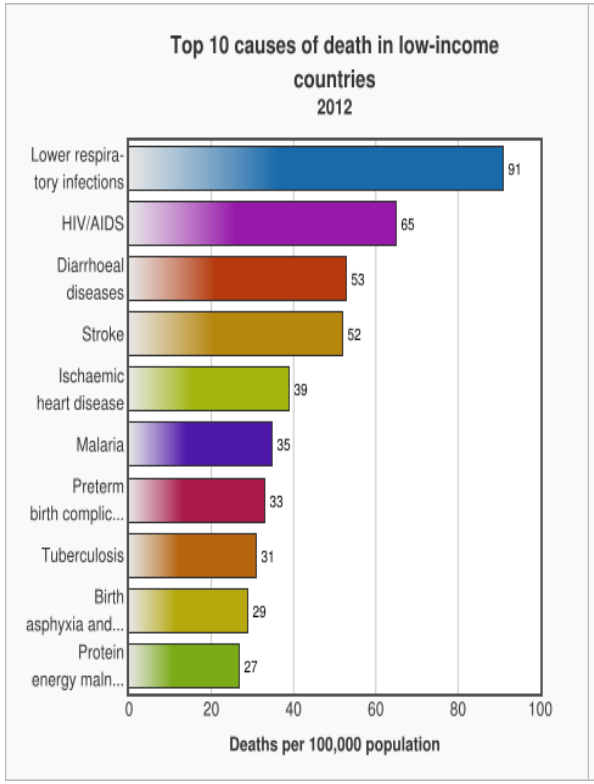
MARQUETTE UNIVERSITY

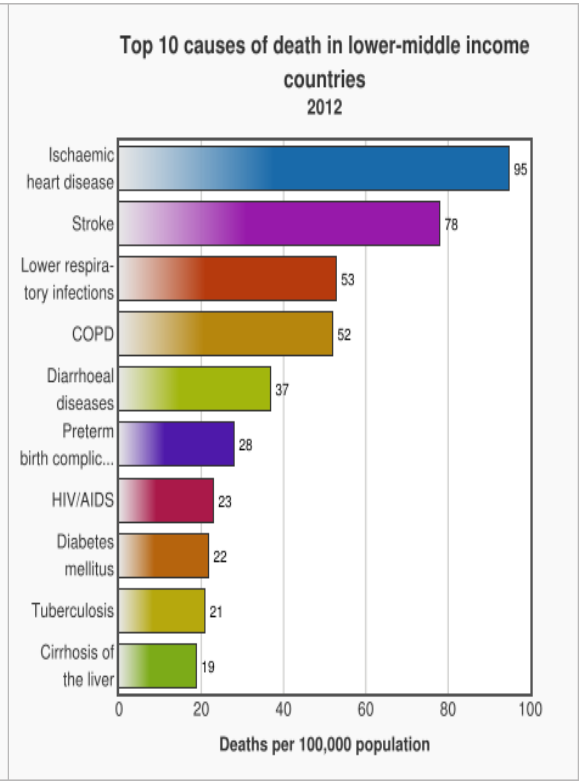
Global Respiratory Health Technology where there is no electricity

Outline

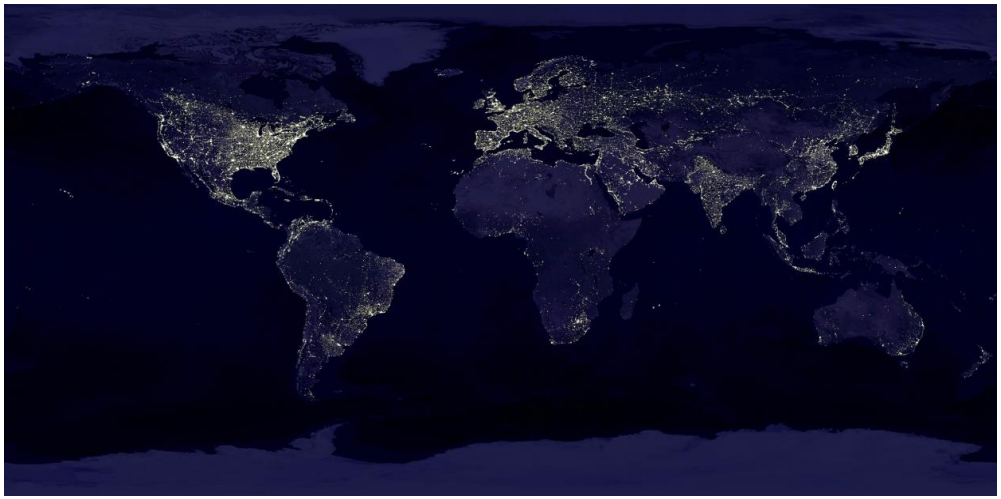
- Respiratory health in low and lower-middle income countries.
- Nebulizer treatments and designs
- Clinical trials and field studies
- Enterprise: Cortinamed
- Future devices


The 10 leading causes of death in the world
2012
Ischaemic heart disease
7.4million
Stroke
6.7million
COPD
3.1million
Lower respiratory in...
3.1million
Trachea bronchus, lu...
1.6million
HIV/AIDS
1.5million
Diarrhœal diseases
1.5million
Diabetes mellitus
1.5million
Road injury
1.3million
Hypertensive...
1.1million
0million
2million
4million
6million
8million
10million

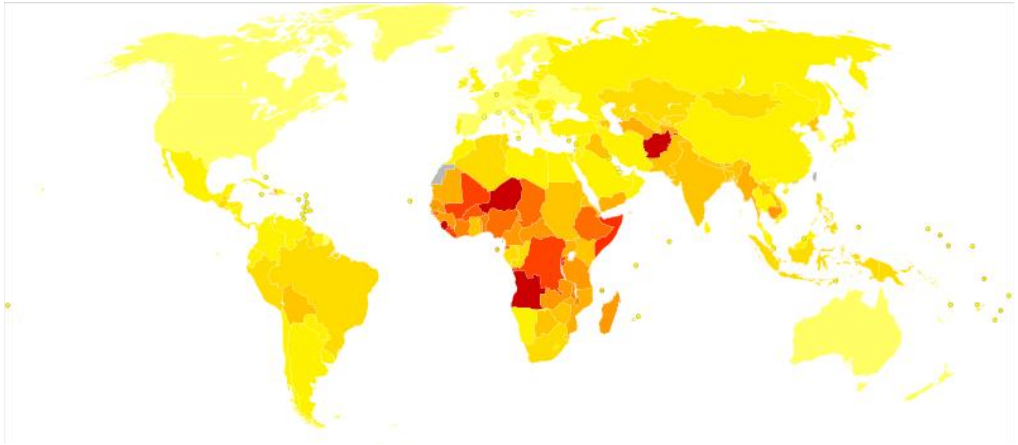

Top 10 causes of death in low-income countries
2012
Lower respira-tory infections
91
HIV/AIDS
65
Diarrhoeal diseases
53
Stroke
52
Ischaemic heart disease
39
Malaria
35
Preterm birth complic...
33
Tuberculosis
31
Birth asphyxia and...
29
Protein energy maln...
27
0
20
40
60
80
100
Deaths per 100,000 population


Top 10 causes of death in lower-middle income countries
2012
Ischaemic heart disease
95
Stroke
78
Lower respira-tory infections
53
COPD
52
Diarrhoeal diseases
37
Preterm birth complic...
28
HIV/AIDS
23
Diabetes mellitus
22
Tuberculosis
21
Cirrhosis of the liver
19
0
20
40
60
80
100
Deaths per 100,000 population

Earth at night



Lower Respiratory Infection Deaths



EL SALVADOR AND GUATEMALA IN 2003-2004

A side debate about global health technologies…

- High Tech Solutions: trickle-down from developed world healthcare.

- Low Tech Solutions: low cost, electricity free "appropriate technology."

Low cost solutions

- Many developing countries spend less than $1 per year per capita on health care

Simple solutions

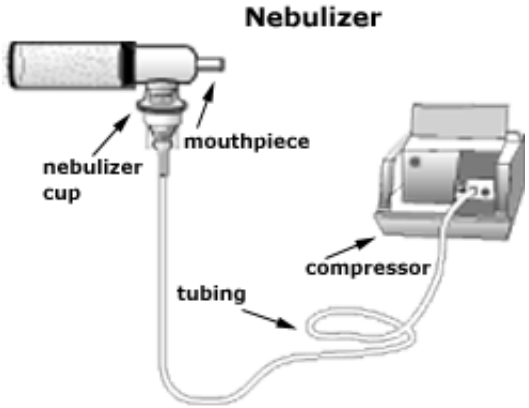
- Highly trained professionals are rarely available

Electricity-free solutions

- Electrical power is not always available

HUMAN POWERED NEBULIZER

What is a Nebulizer?



Compressed air (7l/min) is forced through an orifice submersed in liquid medicine. The medicine is aerosolized into small droplets (approx 5µm dia.) that can be Inhaled deep into the lungs.

Compressed air nebulizers use approx. 1.3 Amps. MDI's with spacers can also be used, and are less expensive in fixed cost, but more drug is wasted. Patient compliance is an issue.

Advantages of a Nebulizer over…

- Inhalers

Requires high degree of patient coordination. Patient compliance is suspect.

A.D.A.M.

- Inhalers with Spacers

Much of the drug gets lost on the spacer walls and is wasted. Overall cost may be higher.

Nebulizer Design Constraints

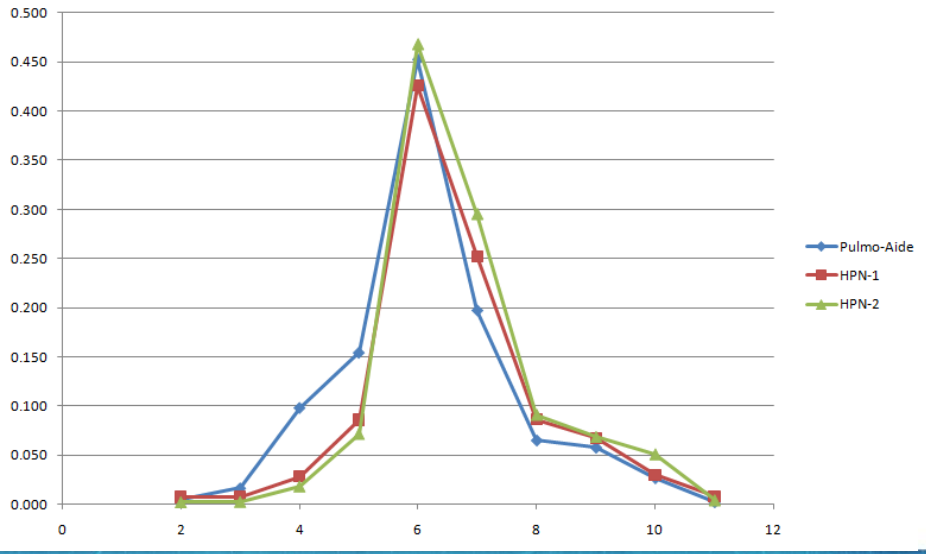
- Low-cost
- Rugged, zero maintenance
- No need for electricity
- Portable
- Highest quality performance (equivalent to electric nebulizer)
- Ability to be built in-country or in developing contexts.

Benchtop Experiments

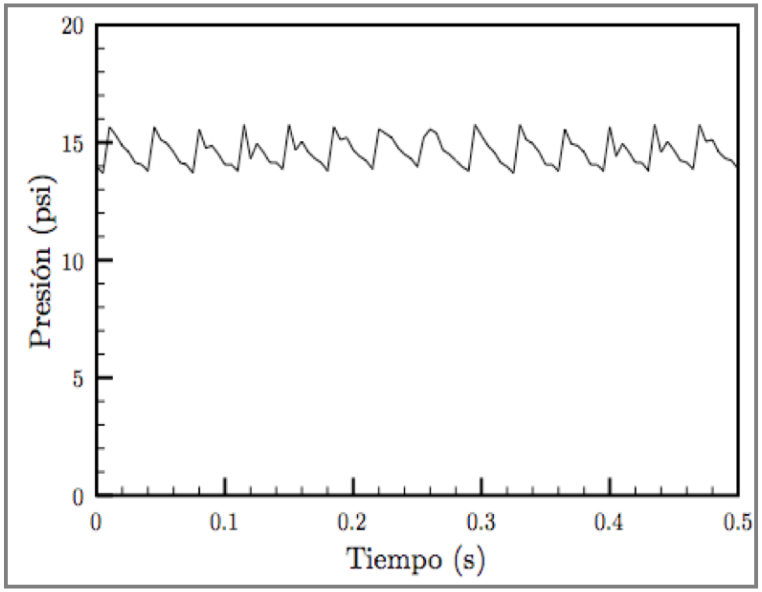
Mass of water delivered in 5 minutes (n=13)

Pulmo-Aide	Human Powered Nebulizer
1.092±0.116 grams	1.097±0.107 grams

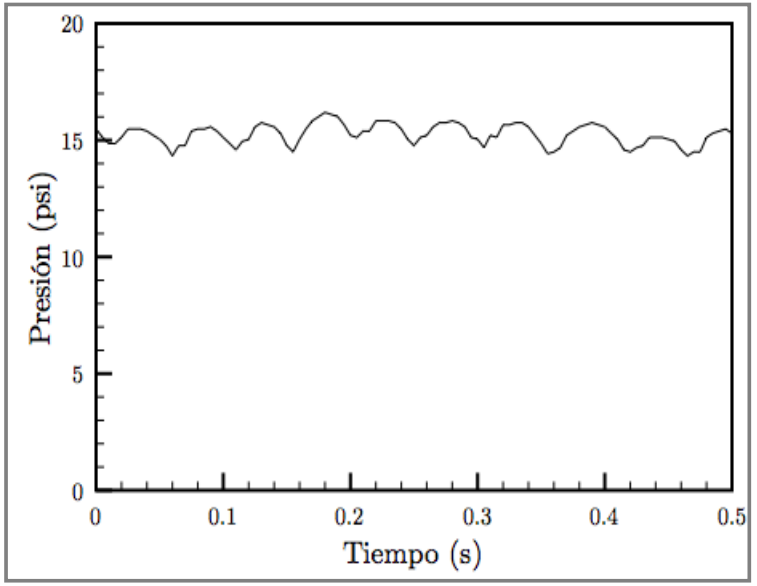
Particle size data as measured with a MOUDI



Bench-top Experiments



Pulmo-Aide



Human-Powered Nebulizer

APPLICATIONS

Diagnosis

Treatment

Prevention

Applications of Human Powered Nebulizers

Diagnosis
- TB – MDR TB/HIV

Treatment
- COPD and asthma
- TB – antibiotics
- LRIs—antibiotics and hypertonic saline

Prevention
- Vaccine delivery

DIAGNOSIS

Tuberculosis

TB Study with the Desmond Tutu HIV Centre, LSHTM, and Northwestern U in Cape Town – Summer 2010

Scoring system	HPN	Pulmo-Aide	P value for test for difference in proportions
	Proportion of good sputum samples	Proportion of good sputum samples	
McCarter	83.5%	74.3%	0.05
Van Scoy	26.5%	22.9%	0.27
Geckler	86.2%	78.0%	0.06
Murray	61.5%	59.6%	0.28
Barlett	27.5%	17.4%	0.04

Larger Scale Study

- TB Diagnosis/Intensified case-finding in Guatemala:
  - Guatemala has the highest prevalence of TB in the Americas.
  - Ministry of Health has a large grant from Global Fund to fight TB in Guatemala.
  - Children of TB+ parents in rural areas are not getting tested.
  - 2000 children in the state of Suchitepeque will get a sputum sample collected and tested in regional centers.

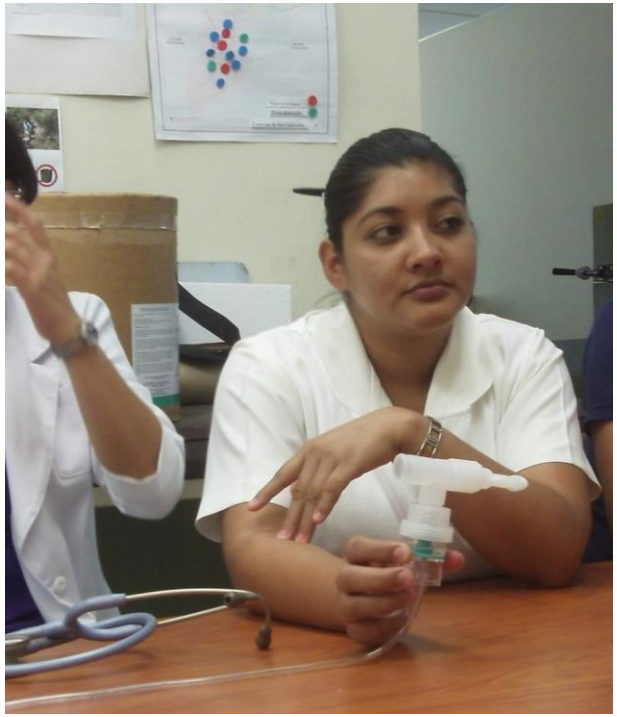
TREATMENT

Lower Respiratory Infections, COPD, and Asthma

El Salvador Studies with Ministry of Health

- Perceptional Studies – Summer 2010
  - Interviews of health professionals, community promoters and community members.
  - Led to molino and treadle designs

El Salvador Studies: CHWs



Clinical Trial of HPN in El Salvador

Table 2: Outcome variables.

	HPN	EN	Mean difference	P-value
Change in PEF - L/min	37.5(26.7-48.2)	38.7(26.1-51.3)	1.3(-15.1-17.7)	0.877
Percent change in expected PEF	12.3(9.1-15.5)	13.8(9.8-17.9)	1.5(-3.6-6.6)	0.552
Percent change in PEF	16.0(11.1-20.9)	19.2(12.3-26.2)	3.2(-5.2-11.6)	0.451
Change in oxygen saturation - percent	1.5(0.8-2.1)	1.8(1.2-2.4)	0.3(-.6-1.2)	0.496

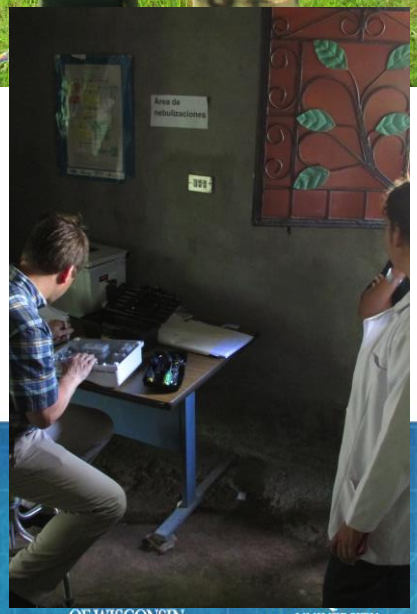
Values are mean (95% CI).

Field Study in El Salvador

- Integration into Ministry of Health
  - ECOS teams
  - *Normas* for reactive airway diseases.

Dra. Rodríguez

Deployment Study in El Salvador



Deployment Study in Guatemala

New Design

- Much less expensive
- Easier to use
- Easier to assemble
- Works at high altitude

Scale Up: Assembly in Suchitoto

Other Technologies

- Suction device for lower respiratory infections for babies
- Low cost ventilator that can run overnight on batteries
- Oxygen concentrator for rural areas

Importance of Place