My Life with Rotaviruses

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NIH Associate Director, International Research Research
Director, Fogarty International Center

Bethesda
April 14, 2015
Disclosures COI

- USG employee – 1979-present
  - CDC holds patents on:
    - Indian RV vaccine strain 116E gifted to the Indo-US Vaccine Program
    - Inactivated Heat Killed Rotavirus vaccine and strains
- No consulting fees or honoraria from pharma

Barbara Stoll, M.D.
Chair of Pediatrics
Emory University School of Medicine
The Legacy of Albert Sabin

Live oral vaccines

Albert Sabin (Fogarty Fellow)

Robert Chanock

Albert Kapikian

Timo Vesikari
My introduction to Enterics! 1999
Bangladesh: The Matlab Barge 1979-1983 and cholera
Diarrhea in Children ~ 1973
5 million deaths per year

**Etiology**

<table>
<thead>
<tr>
<th>Etiology</th>
<th>% explained</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bacteria (Salmonella, shigella, cholera....)</td>
<td>&lt;0-6%</td>
</tr>
<tr>
<td>Parasites (Ameba, ? Giardia)</td>
<td>&lt; 5%</td>
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<tr>
<td>Foods- weanling foods</td>
<td>?</td>
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<tr>
<td>Malnutrition</td>
<td>?</td>
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<tr>
<td>Drugs and allergies</td>
<td>?</td>
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<tr>
<td>Other conditions</td>
<td>?</td>
</tr>
<tr>
<td>“Idiopathic”</td>
<td>&gt; 85%</td>
</tr>
</tbody>
</table>

*How many viruses do you see?*
VIRUS PARTICLES IN EPITHELIAL CELLS OF DUODENAL MUCOSA FROM CHILDREN WITH ACUTE NON-BACTERIAL GASTROENTERITIS
Ruth F. Bishop, G. P. Davidson, I. H. Holmes and B. J. Ruck

Orbivirus
Duovirus
Urbivirus
Reovirus-like agents

What’s happened in 42 years?
Dhaka Hospital

Dhaka Hospital Surveillance

- ~100,000 patients with diarrhea /yr
  - 4% sample - Hx, PE, stools exam
  - Cholera – 6-9%, ~28% RV

B. Stoll, BMJ 1982
Diarrhea
Vomiting
Dehydration
Shock
Death
& ORS!

The face of rotavirus
Essentials of Rotavirus

- Most common cause of severe diarrhea in children
- All children infected by age 5
- “Democratic” virus
- First infections symptomatic
- Natural immunity
- Limited strains in circulation
- Improvements in sanitation won’t prevent infection
IOM Estimates of Rotavirus Deaths--1985

New Vaccine Development
Establishing Priorities

VOLUME II
Diseases of Importance in Developing Countries

Part Two of a Two-Part Study by the Committee on
Issues and Priorities for New Vaccine Development

Diarrheal Deaths (% of total deaths)

873k

Millions

1

0.5

0.1

1980 1990

4.6m 3.3m

High priority for Developing Countries...
IOM Estimates of Rotavirus Deaths--1985

Diarrheal Deaths (% of total deaths)

- 873k
- 527k
- 453k
- 275k
- 0

1980 1990

Millions

1.8m
(18%)
1.3m
(15%)
1.2m
(11%)
4.6m
3.3m

“No need for a RV vaccine for the United States”!
“How can you assess the burden of a disease that is ……

- Rarely diagnosed by lab assay?
- Has no ICD code?
- Symptoms indistinguishable from other childhood diarrheas?
- Requires no specific treatment?
Rotavirus As a Cause of Diarrheal Morbidity and Morality in the United States

Mei-Shang Ho, Roger I. Glass, Paul F. Pinsky, Larry J. Anderson

Winter peaks every year
Children from 3 mo to 3 yrs
High rate of hospitalizations

JID 1988;158 (Nov)

Figure 1. Hospitalizations for childhood gastroenteritis by age group and year.
Diarrhea-associated hospitalizations by month & age among U.S. children < 5 years, 1979-1997
Burden of Rotavirus in the US in Children < 5 years

Risk
- 1 : 10⁶
- 1 : 80
- 1 : 7
- 1 : 0.9

Events
- 20-40 Deaths
- 60-70,000 Hospitalizations
- ~5% of admissions in <5 yr olds
- 500,000 Outpatient visits
- 3.2 Million episodes

Cost: $400 M medical; >$1 B total

Umesh Parashar

Centers for Disease Control and Prevention
Estimated global distribution of ~600,000 annual deaths caused by rotavirus - 1998

85% of deaths – in low income countries

1 dot = 1000 deaths

Parashar U, EIDJ
Identification of Genogroup Astrovirus Gene 4 Types by Polymerase Chain Reaction

JON R. GEBBIE,1 ROGER I. GLASS,1 PATRICIA WOODS,1 VERA GOUEVA,2 MARIO GUERRA-ALVARADO,3 JORGE FLORES,3 BIMAL K. DAS,4 AND M. K. BHAN4
P & G Types of Rotavirus from 66 Studies of Childhood Diarrhea (1993-2003)

- P[8]G4: 7.5%
- P[4]G2: 11.5%
- P[8]G3: 2.8%
- P[6]G9: 5.5%
- P[8]G9: 2.3%
- Other: 18.2%
- Rare strains (23 strains total): P[4]G1 (1.3%), P[6]G2 (0.8%), P[6]G1 (0.6%), P[6]G8 (0.6%), P[4], G3 (0.5%)

N=21,256

J. Gentsch
Regionally Common Rotavirus Strains

Jose P. Leite
Brazil

P[8] G5


Nigel Cunliffe
Malawi


Krisztian Banzai

P[8] G4


P[8] G1
48%
3%
P[8] G4
11%
P[8] G3
3%
6%
P[8] G9
7%
other
7%

Hungary

P[8] G1

42%
P[8] G3
10%

8%

other

mixed

P[8] G5

P[8] G4
P[8] G3
### P and G Types of Human Rotavirus Strains

#### P serotype [genotype]

<table>
<thead>
<tr>
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<td>K8</td>
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<td>2</td>
<td>DS-1</td>
<td>1076</td>
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<td>McN13</td>
<td>AU-1</td>
<td>HCR3</td>
<td>157C</td>
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<tr>
<td>4</td>
<td>Hochi</td>
<td>ST-3</td>
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<td>5</td>
<td>Br1054</td>
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<td>6</td>
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<td></td>
<td></td>
<td>PA151</td>
<td></td>
<td>PA169</td>
<td></td>
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<td>7</td>
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<td></td>
<td></td>
<td>L1166</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>MW333</td>
<td>MW023</td>
<td>69M</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mc323</td>
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<tr>
<td>9</td>
<td>WI61</td>
<td>US1205</td>
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<tr>
<td>10</td>
<td></td>
<td>L26</td>
<td>US585</td>
<td></td>
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</tbody>
</table>

**Legend:**
- **Yellow**: Globally Common
- **Green**: Uncommon
- **Pink**: Regionally Common
- **Blue**: Neonates

![CDC Logo](CDC.png)
How to build a global program?

How to establish need for a vaccine?

<table>
<thead>
<tr>
<th>Sector/Cities</th>
<th>Hospitals</th>
<th>Specimens screened</th>
<th>Rotavirus positives</th>
</tr>
</thead>
<tbody>
<tr>
<td>North</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>National Children’s Hospital</td>
<td>1233</td>
<td>657</td>
</tr>
<tr>
<td></td>
<td>St. Paul’s Children’s Hospital</td>
<td>390</td>
<td>185</td>
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<tr>
<td></td>
<td>Children’s Hospital</td>
<td>886</td>
<td>531</td>
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<td>South</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>General Hospital</td>
<td>589</td>
<td>348</td>
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<tr>
<td></td>
<td>General Pediatrics N. 1</td>
<td>1724</td>
<td>982</td>
</tr>
<tr>
<td></td>
<td>General Pediatrics N. 2</td>
<td>946</td>
<td>544</td>
</tr>
<tr>
<td></td>
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<td>5768</td>
<td>3247</td>
</tr>
</tbody>
</table>

*Van Mann, et al., JID, 2001*

**Dr. Trang**
Rotavirus Hospitalizations in the Asian Rotavirus Surveillance Network

China: 41%
Korea: 38%
Taiwan: 41%
Vietnam: 60%
Malaysia: 56%
Indonesia: 39%
Myanmar: 56%
Hong Kong: 29%
Tools for Global Rotavirus Surveillance

Bernard Ivanoff

Duncan Steele
WHO- Rotavirus Surveillance Network: Jan-Dec 2011
64 Countries

Number of Children <5 years enrolled = 45,827

sentinel sites = 185

Source: WHO/IVB New Vaccines database
Data collected from WHO Regions.

58 Member States reported clinical data

6 Member States reported genotype data only
Each point = country team in EPI, lab, Public Health Champions!

36%
An Epidemic of Publications
Chapter 2

The rise and fall of Rotashield!

Dealing with Disaster!
February 1998

The New York Times
F.D.A. Approves Vaccine for Childhood Diarrhea

Albert Kapikian
NIH

Rhesus Tetravalent vaccine-Rotashield
## Childhood Immunization Schedule
### United States, January – December 1999

<table>
<thead>
<tr>
<th>Age</th>
<th>Vaccine</th>
<th>Birth</th>
<th>1 mo</th>
<th>2 mos</th>
<th>4 mos</th>
<th>6 mos</th>
<th>12 mos</th>
<th>15 mos</th>
<th>18 mos</th>
<th>4-6 yrs</th>
<th>11-12 yrs</th>
<th>14-16 yrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth</td>
<td>Hep B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hep B</td>
<td></td>
<td>MMR</td>
</tr>
<tr>
<td>1 mo</td>
<td>Hep B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>DTaP</td>
<td></td>
<td>Polio</td>
</tr>
<tr>
<td>2 mos</td>
<td>DTaP</td>
<td>Hep B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Hib</td>
<td></td>
<td>MMR</td>
</tr>
<tr>
<td>4 mos</td>
<td>Hib</td>
<td>DTaP</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Hib</td>
<td></td>
<td>Polio</td>
</tr>
<tr>
<td>6 mos</td>
<td>Hib</td>
<td>Hib</td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<td>Hib</td>
<td></td>
<td>Polio</td>
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<tr>
<td>12 mos</td>
<td>Hib</td>
<td>Hib</td>
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<td></td>
<td></td>
<td></td>
<td>Hib</td>
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<td>Polio</td>
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<tr>
<td>15 mos</td>
<td>Hib</td>
<td>Hib</td>
<td></td>
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<td></td>
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<td></td>
<td>Hib</td>
<td></td>
<td>Polio</td>
</tr>
<tr>
<td>18 mos</td>
<td>Hib</td>
<td>Hib</td>
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<td></td>
<td></td>
<td>Hib</td>
<td></td>
<td>Polio</td>
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<tr>
<td>4-6 yrs</td>
<td>DTaP</td>
<td>DTaP</td>
<td></td>
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<td>DTaP</td>
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<td>Polio</td>
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<tr>
<td>11-12 yrs</td>
<td>DTaP</td>
<td>DTaP</td>
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<td>DTaP</td>
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<td>Polio</td>
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<tr>
<td>14-16 yrs</td>
<td>DTaP</td>
<td>DTaP</td>
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<td>DTaP</td>
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<td>Polio</td>
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<tr>
<td>14-16 yrs</td>
<td>DTaP</td>
<td>DTaP</td>
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<td></td>
<td></td>
<td></td>
<td>DTaP</td>
<td></td>
<td>Polio</td>
</tr>
</tbody>
</table>

- **Hep B**: Hepatitis B
- **Hib**: Haemophilus influenzae type b
- **IPV**: Inactivated Poliovirus Vaccine
- **DTaP**: Diphtheria, Tetanus, Acellular Pertussis
- **Polio**: Poliomyelitis
- **MMR**: Mumps, Measles, Rubella
- **Var**: Varicella
- **Rv**: Rotavirus
What is Rotavirus?
Why don’t I know about it?
Rotavirus Vaccines - “low hanging fruit” for new vaccine development

- Disease burden is large & global
- Principles to develop vaccines are well established
- Extensive past experience with clinical trials
- Achievable in 5-7 years
- Impact of vaccine should be measurable within one year
Pasteur Award - Children’s Vaccine Initiative
Geneva, November, 1998
Intussusception Among Recipients of Rotavirus Vaccine — United States, 1998–1999

On August 31, 1998, a tetravalent rhesus-based rotavirus vaccine (RotaShield®, Wyeth Laboratories, Inc., Marietta, Pennsylvania) (RRV-TV) was licensed in the United States for vaccination of infants. The Advisory Committee on Immunization Practices (ACIP) also announced that it was recommending universal use of RRV-TV for infants 6 through 23 weeks of age in the United States. The manufacturer had submitted a complaint to the U.S. Food and Drug Administration (FDA) regarding a possible link between the vaccine and intussusception. Based on the report of the Association of State and Territorial Epidemiologists (1), the manufacturer concluded that the data did not support a causal relationship between the vaccine and intussusception. However, a subsequent analysis by the CDC (2) of the Vaccine Adverse Event Reporting System (VAERS) data suggested that there may be an increased risk of intussusception following RRV-TV vaccination.

Intussusception

The telescoping of the intestine onto itself usually at the ileal-cecal junction, leading to reversible repair or entrapment with edema, necrosis and perforation.
1999: The “I” word sinks Rotashield
The 2nd Question
What to do? The Dilemma

Dr. Phil Russell

- The global need for a RV has been established!
- Wyeth Lederle hadn’t planned for global supply!
- Loss of Rotashield provides space for competition!
- Emerging manufacturers could make similar vaccines!
- If we had tested simultaneously in LMICs, Rotashield might still be with us today!
- We may now be better off than expected!
Safety and Efficacy of a Pentavalent Human–Bovine (WC3) Reassortant Rotavirus Vaccine
Timo Vesikari, M.D., David O. Matson, M.D., Ph.D., Penelope Dennehy, M.D., Pierre Van Damme, M.D., Ph.D., Mathuram Santosham, M.D., M.P.H., Zoe Rodriguez, M.D., Michael J. Dallas, Ph.D., Joseph F. …..

Safety and Efficacy of an Attenuated Vaccine against Severe Rotavirus Gastroenteritis
Guillermo M. Ruiz-Palacios, M.D., Irene Pérez-Schael, M.Sc., F. Raúl Velázquez, M.D., Hector Abate, M.D., Thomas Breuer, M.D., SueAnn Costa Clemens, M.D., Brigitte Cheuvart, Ph.D., Felix Espinoza, M.D., Paul Gillard, M.D., Bruce L. Innis, M.D., Yolanda Cervantes, M.D., ….
2 New Rotavirus Vaccines

GSK *Rotarix*

- Human rotavirus
- G1P[8]
- 2 doses $10^6$
- Shedding $>50\%$
- Efficacy $>85\%$

**Trials of both > 60,000 !**

Merck *RotaTeq*

- G1
- P[8]
- G2
- G3
- G4
- 3 doses $10^8$
- Shedding < 10
- Efficacy > 90\%
CDC Advisory Committee on Immunization Practices (ACIP) – Feb. 2006

Recommendations for Pentavalent Bovine-Human Rotavirus Vaccine (PRV)

- Routine immunization of infants with 3 doses of PRV at 2, 4, and 6 months of age
- Three doses at 2, 4, and 6 months of age
- Dose 1 between 6-12 weeks of age
- All doses by 32 weeks of age
- 4-10 week interval between doses
Percent of children receiving RV vaccines
National Immunization Survey, 2009-2013
US children 19-35 months old

Centers for Disease Control and Prevention, *MMWR* 2014
Total number of rotavirus tests and positive results* from 24 continuously reporting laboratories - National Respiratory and Enteric Virus Surveillance System, United States, July 8, 2000 - June 30, 2012

*3-week moving average
Impact of Rotavirus Vaccine in the US
A Review of studies

Kansas City, MO\textsuperscript{4}
\textbf{88\% reduction}
Hospitalization

Galveston, TX\textsuperscript{3}
\textbf{94\% reduction}
Hospitalization or ED

Philadelphia, PA\textsuperscript{1}
\textbf{87\% reduction}
in Community acquired cases (Children's Hosp.)

Philadelphia, PA\textsuperscript{2}
\textbf{94\% reduction}
Hospitalization (St Chris)

Worcester, MA\textsuperscript{5}
\textbf{95\% reduction}
Hospitalization, ED, *Outpatient

New York State\textsuperscript{6}
\textbf{85\% reduction}
Hospitalization/ED

Consequences have been enormous!
Greater than rates of immunization!
The Impact of RV Vaccination in the United States

• ~50,000 fewer hospitalizations per year
• Fewer winter doctor/clinic visits
• Indirect effects on older children & adults
• No change in the distribution of strains
• Low rate of intussusception
• Partial protection with one or two doses
• 20% reduction in seizures in children
Childhood Diarrhea Deaths after Rotavirus Vaccination in Mexico

40% decrease in deaths!

Figure 1. Number of Diarrhea-Related Deaths among Children 59 Months of Age or Younger from July 2002 through December 2010 in Mexico, According to Age Group.

Richardson V et al. NEJM 2012
WHO Recommends Global Use of Rotavirus Vaccines

5 JUNE 2009 | GENEVA/SEATTLE -- WHO has recommended that rotavirus vaccination be included in all national immunization programs to provide protection against a virus that is responsible for more than 500,000 diarrheal deaths and 2 million hospitalizations every year among children. More than 85% of these deaths occur in developing countries in Africa and Asia.

**Schedule:** 2 doses 6 & 10 weeks
First dose 6-15 wks; last 32 wks
Given with EPI vaccines

Recommendations extended to Rotateq ~ 12/09
What about the developing world?

“Can rotavirus vaccines prevent death among children in the poorest countries...and if so, how rapidly can these vaccines be introduced?”
Oral vaccines worked less well in the places they are needed most!

Tony Nelson, Lancet 2010
OPV doesn’t work as well in Indian children and we don’t know why!
Hurdles to Immunization for a Live Oral Rotavirus Vaccine

Factors that lower viral titer

- Breast milk
- Stomach acid
- Maternal antibodies

Factors that impair immune response

- Malnutrition - Zn, Vit A
- Interfering microbes - viruses and bacteria
- Other infections - HIV, malaria, TBC
The Remaining Hurdles

Vaccine Efficacy
Finance & Supply
New Approaches & Vaccines

Past Hurdles
Vaccines Licensed
GAVI funding
Global recognition
WHO recommendation
Safety- Intussusception, PCV…
What are the alternatives?

• Live oral vaccines
  - Neonatal strains
    - Rotavac – India
    - RV3 Australia- Indonesia
  - Rotashield revisited
  - UK Bovine reassortants

• Parenteral vaccines
  - Inactivated virus (IRV)
    - Virus Like particles (VLPs)
    - Expressed proteins- VP6, VP4

Baoming Jiang
Chapter 3

Who will pay for new rotavirus vaccines?

How will we resolve the cost issues?
Vaccine campaign to target deadly childhood diarrhoea

Programme to guard against second-biggest killer of under-fives rolls out across Africa.

BY DECLAN BUTLER

29 SEPTEMBER 2011 | VOL 477 | NATURE |
National RV introductions by region: April 1, 2015, 77 countries*

*As of April 1, 2015
RV = rotavirus vaccine
Drug firms cut vaccine prices to the developing world*

<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>PAHO</th>
<th>GAVI / UNICEF</th>
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<tbody>
<tr>
<td>GSK</td>
<td>$120 – $200/child</td>
<td>$15/child</td>
<td>$5/child [up to 125 M doses; over 5 yrs]</td>
</tr>
<tr>
<td>Merck</td>
<td>$120 – $200/child</td>
<td>$15.45/child</td>
<td>$10.50/child [for volume over 30 M]</td>
</tr>
</tbody>
</table>

- 3 doses/child: Merck, Bharat Biotech
- 2 doses/child: GSK
* Applies to GAVI tenders
10 Countries with the most Rotavirus deaths

<table>
<thead>
<tr>
<th>Country</th>
<th>Death Rate (%)</th>
<th>Deaths</th>
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<tbody>
<tr>
<td>India</td>
<td>21.8%</td>
<td>98,621</td>
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<tr>
<td>Nigeria</td>
<td>9.1%</td>
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<td>Pakistan</td>
<td>8.6%</td>
<td>39,144</td>
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<tr>
<td>DR Congo</td>
<td>7.2%</td>
<td>32,653</td>
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<td>Ethiopia</td>
<td>6.2%</td>
<td>28,218</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>5.6%</td>
<td>25,423</td>
</tr>
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<td>Uganda</td>
<td>2.3%</td>
<td>10,637</td>
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<tr>
<td>Indonesia</td>
<td>2.2%</td>
<td>9,970</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>2.2%</td>
<td>9,857</td>
</tr>
<tr>
<td>Angola</td>
<td>1.9%</td>
<td>8,788</td>
</tr>
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</table>

Largest burden
Large vaccine industry
Use domestic vaccines
Low cost - essential

Seminal observation, 1985

“Outbreak” of RV infection among Newborns in New Delhi (AIIMS)

- Asymptomatic infections -- 50% by day 3
- Prolonged viral shedding – >7 days
- Unusual strain – G9 P11 bovine human reassortant
- Good immune response
- Children protected from severe RV disease on reinfection!

Could this be a potential vaccine candidate?
First visit to Bharat! 2001

Collaborators

AIIMS;  M.K. Bhan, N.Bhandari, IISc. Bangalore:  C.D. Rao

IISc. Bangalore:  H. Greenberg

Stanford University:  – H. Greenberg

CDC:  R. Glass, U. Parashar, J. Gentsch

Bharat BioTech,  – Krishna Ella, Sai Prasad G. Harshavardhan, K.Mohan
Preparing for Phase 3 Trial

Indian RV project

- M.K. Bhan, Dept. of Biotechnology
- Nita Bhandari, Society for Applied Studies
- John Boslego, PATH
- Harry Greenberg, Stanford University
- NIH George Curlin
- Krishna Ella, Bharat Biotech
- & hundreds of staff, field workers, and parents whose children participated in these studies.

Dr. Krishna Ella

M.K. Bhan
### Efficacy of a monovalent human-bovine (116E) rotavirus vaccine in Indian infants: a randomised, double-blind, placebo-controlled trial

Bhandari, et al. June 2014

<table>
<thead>
<tr>
<th>Endpoints</th>
<th>ROTAVAC N= 4354</th>
<th>Placebo N= 2187</th>
<th>Vaccine Efficacy % (95% CI)</th>
<th>p value</th>
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<tr>
<td><strong>Severe RV GE requiring hospitalization# or supervised rehydration therapy$</strong></td>
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<td>Till 2 yrs of age</td>
<td>92 (2%)</td>
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<td>55.6% (40.5, 66.8)</td>
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*Protects in yr. 2
India is taking the lead for RV vaccines in Asia

- 2 New Vaccines from India
  - Rotavac licensed 2014
    - Bharat Biotech
  - UK reassortant – in trial - Serum Institute of India

Prime Minister Modi

“Government of India will provide a rotavirus vaccine to all Indian children”
P.M. Modi launches Rotavac - 1st Indian vaccine against rotavirus, New Delhi, March 9, 2015

“This is the most exciting event to happen in vaccine development in India for nearly a century!" Dr. Harsh Vardhan, Min. of S & T
First child receiving licensed Rotavac
Estimates of Rotavirus Deaths: 2012

Diarrheal Deaths (% of total deaths)

- 1980: 4.6m (18%)
- 1990: 3.3m (15%)
- 2000: 1.8m (18%)
- 2010: 1.3m (15%)
- 2012: 0.7m (11%)

Institute of Medicine of the National Academies

CDC

CHERG
Where are we now?

- WHO recommendation & GAVI funding have sparked introductions in low income countries
- 77 countries have introduced RV vaccines
- The impact is enormous! Herd effect unanticipated!
- Evaluation of impact essential to assess lower efficacy but positive herd effects

*Research is essential - to improve existing vaccines, develop less expensive & more effective alternatives*
We have a lot to celebrate!

We still have a lot more to do…….
CDC: The Viral Gastroenteritis Group 2006

- 25 EIS officers, 30 post-docs
- Trainees from >50 countries
- Visiting scientists, >500 papers
The Viral Gastroenteritis Section Today

Daniel Payne
Jackie Tate
Umesh Parashar
Ben Lopman
Margaret Cortese
Manish Patel
Jon Gentsch
Umesh Parashar
Baoming Jiang
Margaret Cortese
Ben Lopman
Eyal Leshem
The Home Team!