Strengthening Vaccine Supply Chains: A systems approach using HERMES (Highly Extensible Resource for Modeling Event-Driven Supply Chains)

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What is a system?

- Transportation systems
- Ecological systems
- Manufacturing systems
- Meteorological systems
- Financial systems
- Aerospace systems
What is a systems approach?

- Convene multidisciplinary teams
- Create mathematical and computational models to represent system
- Elucidate important factors and relationships
- Guide and prioritize data collection
- Test different policies and interventions
- Inform stakeholders
- Design and implement interventions
- Update models
Why do we need to take a systems approach?

- Unsustainable solutions
- Band-aids rather than solutions
- Expended time, effort, and resources from trial and error
- Overlooked secondary and tertiary effects
- Unintended outcomes

Need for systems science approach
Why focus on the supply chain?

Are Vaccines Getting To Where They Need To Go?

By Judith R. Kaufmann, Roger Miller, and James Chaynes

Vaccine Supply Chains Need To Be Better Funded And Strengthened, Or Lives Will Be At Risk

No product, no program: The critical role of supply chains in closing the immunization gap *

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Vaccine delivery is a complex system

- Biological Properties
- Presentation
- Accessories
- Cost
- Vaccine
- Distribution
- Administration
- Other Interventions
- Vaccine Delivery
- Infrastructure
- Education
- Employers
- Social Structure
- Third Party Payers
- Health Care System
- Disease Epidemiology
- Economics

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HERMES is a systems modeling tool for decision support

Create a freely available and user-friendly software tool for decision makers to generate an interactive simulation model of any supply chain (= a virtual laboratory).

Data on supply chain structure, storage locations, transport, capacities, personnel, etc.

Standard input deck

Discrete event simulation model of supply chain

Guide data collection

ID & assess options

Test strategies
Example topics HERMES has addressed

- Introducing new vaccines and technology
  e.g. vaccines, storage, vehicles
- Altering characteristics of vaccines and other technologies
  e.g. vaccine vial size, vaccine thermostability, cold device capacity
- Changing configuration and operations of the supply chain
  e.g. storage, shipping frequency, personnel, ordering policy
- Differing conditions/circumstances
  e.g. power outages, delays, inclement weather, limited access
- Investing or allocating resources
  e.g. adding refrigerators vs. increasing transport frequency
- Optimizing vaccine delivery
  e.g. minimize cost, cost per outcome, maximize immunizations
Making vaccines thermostable

The impact of making vaccines thermostable in Niger’s vaccine supply chain

Bruce Y. Lee, Brigid E. Cakouros, Tina-Marie Assi, Diana L. Connor, Joel Welling, Souleymane Kone, Ali Djibo, Angela R. Wateska, Lionel Pierre, Shawn T. Brown

Thermostable vaccine

Baseline Pentavalent TT YF BCG M OPV

Vaccine Availability

80% 82% 84% 86% 88% 90% 92% 94% 96% 100%

Pentavalent
TT
YF
BCG
M
OPV

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Evaluating solar refrigerators

Fig. 2. Conditions under which solar powered refrigerators can provide savings over electric refrigerators at health facilities. The maximum annual cost for each solar device (including amortization and maintenance) that can provide savings over electric mains-powered refrigerators in total cost per dose administered at the health facility level is shown when electrical outages of varying frequency and duration occur at all health facilities. Results assume the electric refrigerator holdover time exceeds the duration of the outage.
Redesigning the system

The benefits of redesigning Benin’s vaccine supply chain

Shawn T. Brown\textsuperscript{a}, Benjamin Schreiber\textsuperscript{b}, Brigid E. Cakouros\textsuperscript{c,1}, Angela R. Wateska\textsuperscript{c,1}, Hamadou M. Dicko\textsuperscript{d,e}, Diana L. Connor\textsuperscript{c,1}, Philippe Jaillard\textsuperscript{d,e}, Mercy Mvundura\textsuperscript{f}, Bryan A. Norman\textsuperscript{g}, Carol Levin\textsuperscript{h}, Jayant Rajgopal\textsuperscript{g}, Mélanie Avella\textsuperscript{d,e}, Caroline Lebrun\textsuperscript{d,e}, Erin Claypool\textsuperscript{g}, Proma Paul\textsuperscript{g}, Bruce Y. Lee\textsuperscript{c,1,*,1}

Cumulative Cost Savings over Current Augmented System

- Zone Sanitaire: Motorcycles, no loops
- Zone Sanitaire: 4 HCs per loop
- Zone Sanitaire: 6 HCs per loop
- Zone Sanitaire: 10 HCs per loop
- Commune Removed: 10 HCs per loop
- Commune Removed: 12 Departments: 10 HCs per loop

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HERMES
HIGHLY EXTENSIBLE RESOURCE MODELING EVENT-DRIVEN SUPPLY CHAINS

Pittsburgh Supercomputing Center

Johns Hopkins Global Obesity Prevention Center
Assessing alternative transport

The economic and operational value of using drones to transport vaccines

Leila A. Haidari\textsuperscript{a,b}, Shawn T. Brown\textsuperscript{a,b}, Marie Ferguson\textsuperscript{c,d}, Emily Bancroft\textsuperscript{e}, Marie Spiker\textsuperscript{c,d}, Allen Wilcox\textsuperscript{e}, Ramya Ambikapathi\textsuperscript{c,d}, Vidya Sampath\textsuperscript{e}, Diana L. Connor\textsuperscript{a,d}, Bruce Y. Lee\textsuperscript{a,c,d,e}

Maximum UAV and Hub Costs\textsuperscript{*} to Produce Cost Savings Over TMLTS (EPI with Rota, IPV, MSD, and HPV Introductions), Where Each Flight Has a 50% Probability of Delay

\begin{figure}
\centering
\includegraphics[width=\textwidth]{cost_savings.png}
\caption{Cost savings graph for UAV and Hub costs over different durations of delay.}
\end{figure}
HERMES 1.0 now available @ hermes.psc.edu

The Journey Matters: Why Vaccine Supply Chains Deserve Much More Attention

Next generation vaccine supply chain software available
User-friendly supply chain software can help guide decision makers through a hands-on approach
Sarah Robbins, Johns Hopkins Bloomberg School of Public Health

HERMES Public Health Modeling Software Released for Public Use
April 23, 2018
April 23, 2018 — Public health experts at the International Vaccine Access Center (IVAC) at Johns Hopkins University and the Johns Hopkins Center for Global Health (JHCGH) have launched HERMES, a tool designed to help decision makers improve vaccine supply chains. HERMES provides an opportunity for decision makers to better understand the impact of their decisions on vaccine supply chains, and to evaluate the possibilities of alternative strategies.

HERMES is a highly flexible, extensible resource modeling event-driven supply chain model. It allows users to create and simulate vaccine supply chains for individual countries or groups of countries, and provides detailed, real-time feedback on key performance indicators such as vaccine delivery, storage, and waste.

HERMES has been developed by a team of experts from the Center for Global Health, the International Vaccine Access Center, and the Johns Hopkins Bloomberg School of Public Health. The software is free and open-source, and is available for public use through the HERMES website.

HERMES Create A Model

HERMES Simulation Results

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Systems Science Core Team

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Thank you