Operations Research Mini Course

University of Washington Center for AIDS Research

Scientific Program on
Health Services and Strategies Research

July 27, 2007

CFAR
CENTER FOR AIDS RESEARCH
University of Washington

Agenda

Time	Session	Presenter
9:00 – 9:15	Welcome	Steve Gloyd, MD, MPH
9:15 –10:00	Introduction to OR	Mark Micek, MD, MPH
10:00 – 10:45	OR modeling	Eva Lee, PhD
10:45 – 11:00	Break	
11:00 – 11:45	OR modeling in ARV programs	Bill Rodriguez, MD
11:45 – 12:30	Qualitative methodologies in OR	James Pfeiffer, PhD, MPH
12:30 – 1:45	Lunch	
1:45 – 2:30	Experimental methodologies in OR	James Hughes, PhD
2:30 – 3:15	Ethics and OR	Steve Gloyd, MD, MPH
3:15 – 4:00	From OR to policy change	Wendy Johnson, MD, MPH

An Introduction to Operations Research

------- or -------

How can I make my health program better?

Mark Micek, MD, MPH

Operations Research Mini Course

July 27, 2007

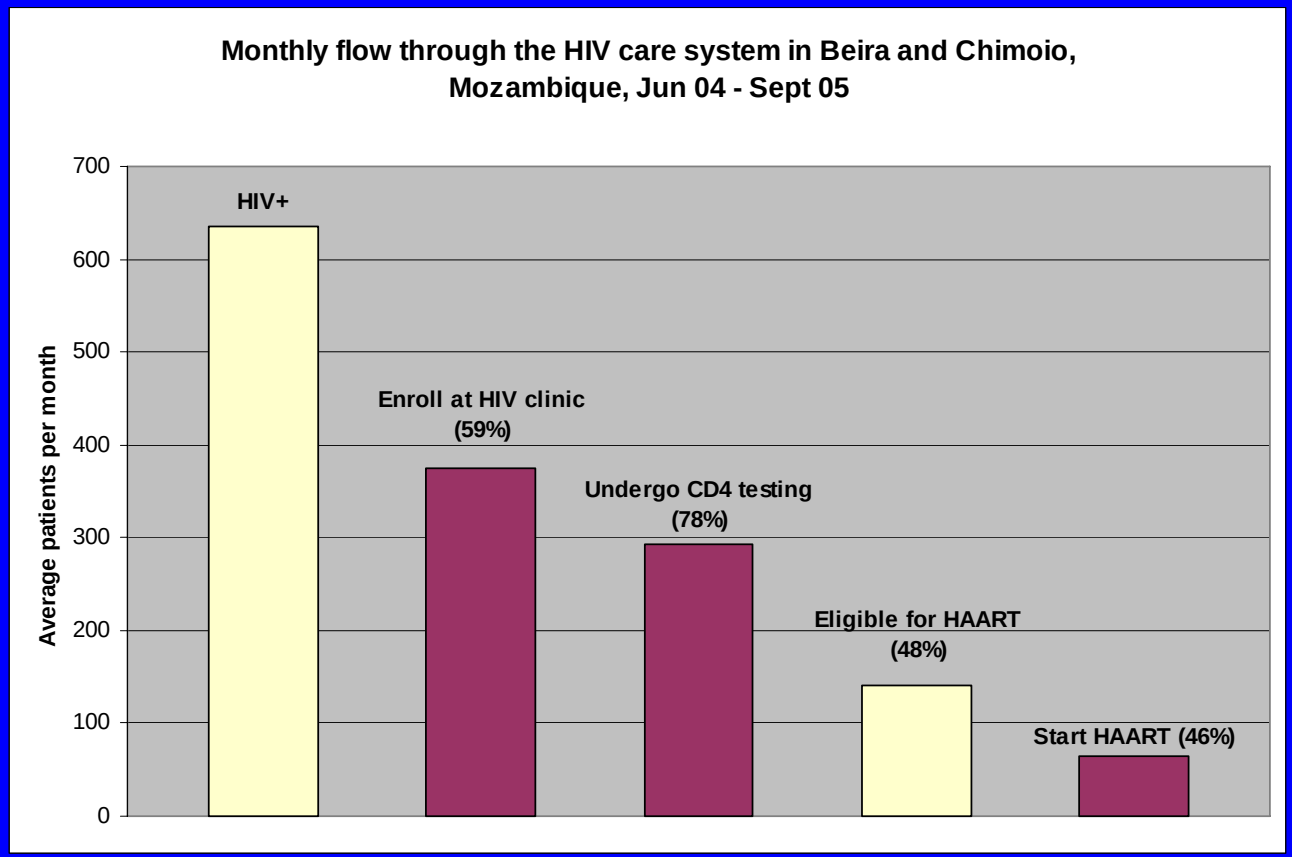
The Issue

- It is difficult to…
  …effectively deliver scientifically proven health interventions in the “real world”
  …translate research into health program settings

- Why?
  - Research generally occurs in controlled settings
    - Homogenous sample, controlled setting
  - Health programs exist in a complex setting
    - Heterogeneous clients, multiple settings
    - Dependent on external context of care-delivery system
      - i.e. policy, resource availability ($ and personnel), community perceptions

Example of difficulty translating proven treatment into practice

- HAART reduces mortality among patients with HIV
  - BUT many eligible HIV-positive people don't start HAART



How can we improve the performance of our programs in an evidence-based way?

- Use the principles of Operations Research

What is OR?
Generic definition

- "[Application of] scientific methods to decision making in complex real world problems which are concerned with coordination and execution of the operations within an organization"

- Goal = find a best possible solution to improve performance of the organization

  - Early examples in military, business
  - Use data, statistics, mathematical modeling
  - Synonym = "management science"

3 Core Principles of OR

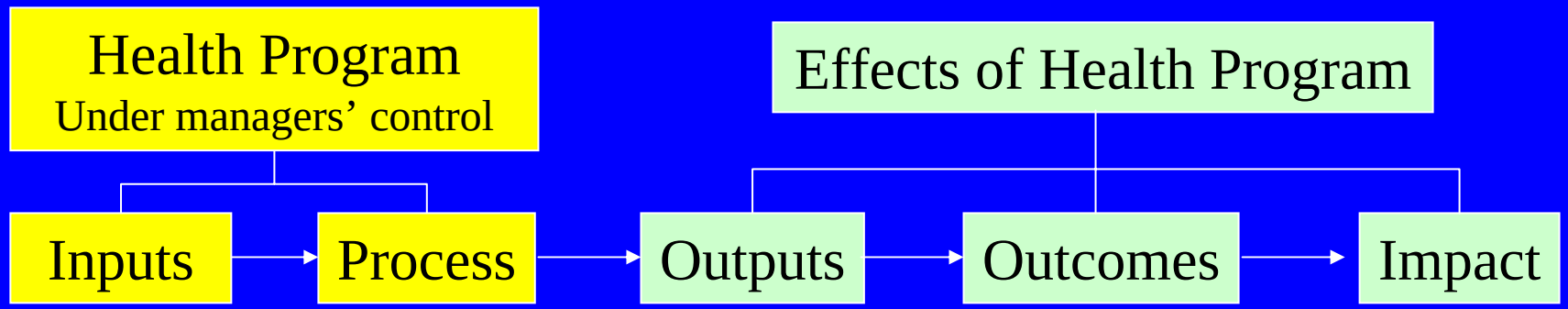
1. Study health programs
2. Actively try to make the program better
3. Use results to improve the program

Corollary: requires collaboration between managers and researchers

Core principle of OR #1: Study health programs

- Health program is key to health care delivery
  - OR usually focuses on existing program
- Research problem = program problem
- Research intervention = program solution
  - Feasible within context of entire system
- Assures problems and solutions are defined by realities of the health program system

Health program as system



Raw Materials:

- Finances
- Costs
- Staff
- Facilities

Activities:

- Trainings
- Supervision
- Logistics
- Reporting
- Record keeping
- Patient flow strategies

Products of program activities:

- # condoms distributed
- # people tested for HIV
- # enrolling for HIV care

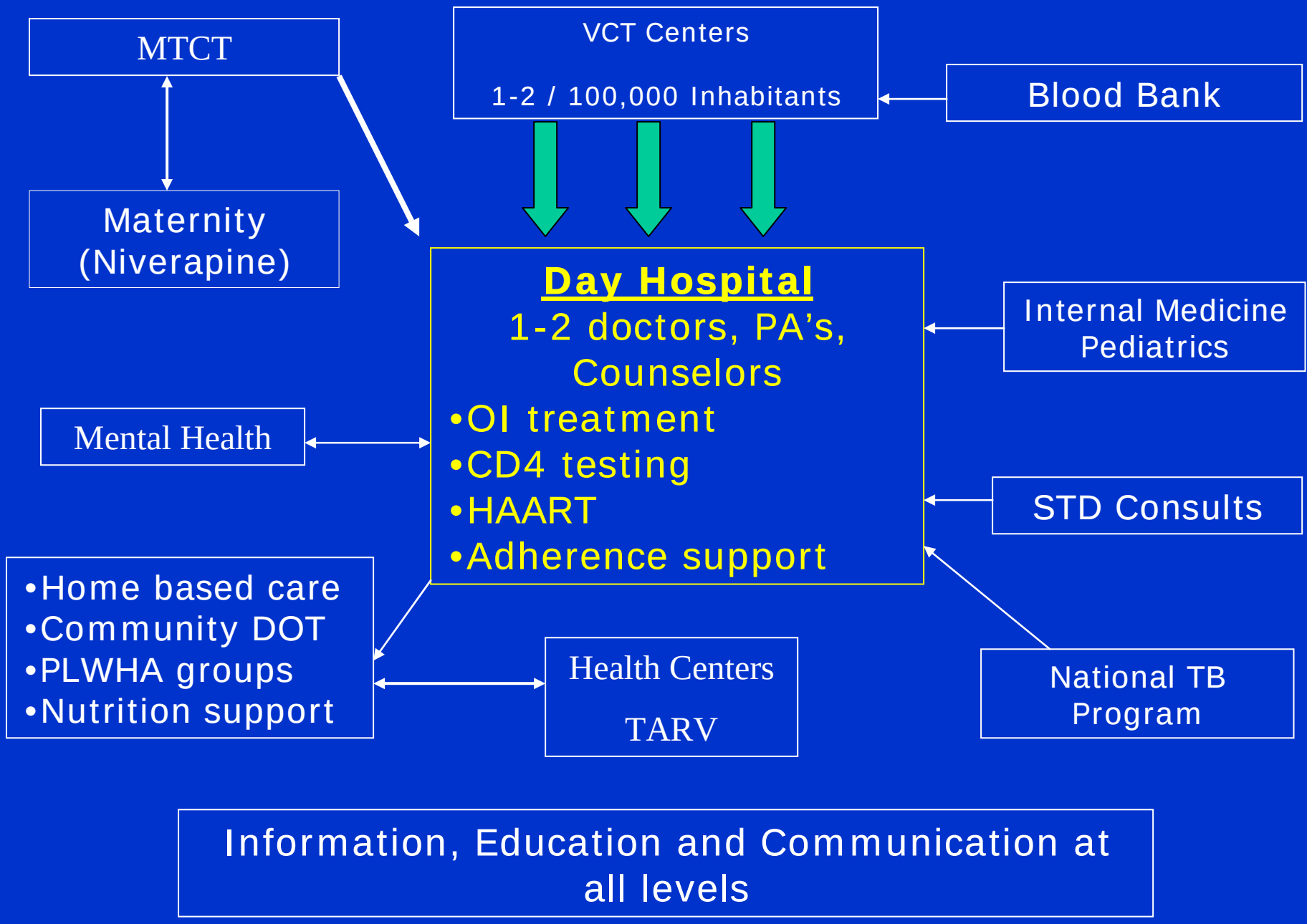
Effect on knowledge or behavior:

- # youth using condoms
- # women using pMTCT services
- # starting ARVs
- % adhering to ARVs

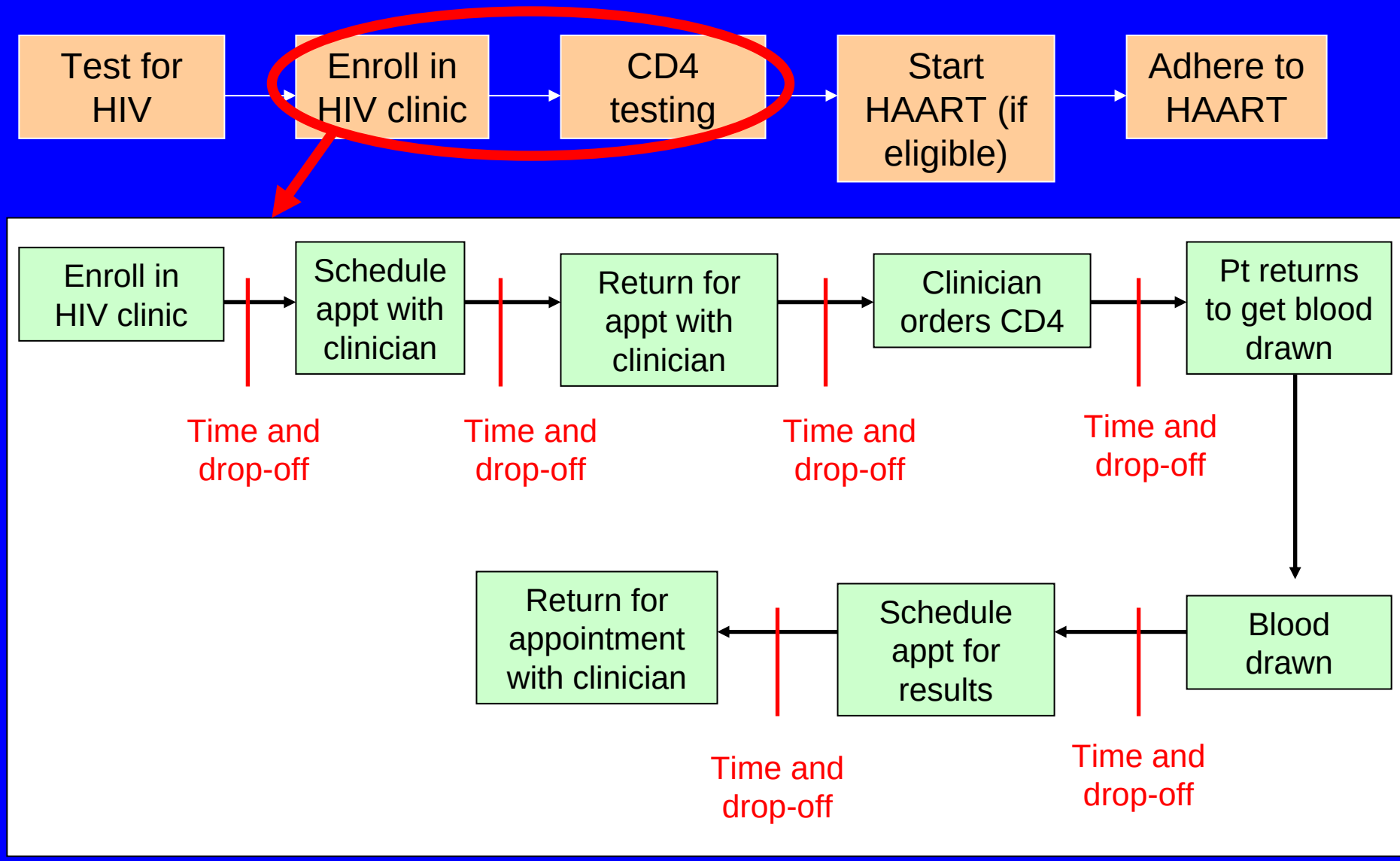
Change in health/well-being

- HIV/STD incidence
- # deaths

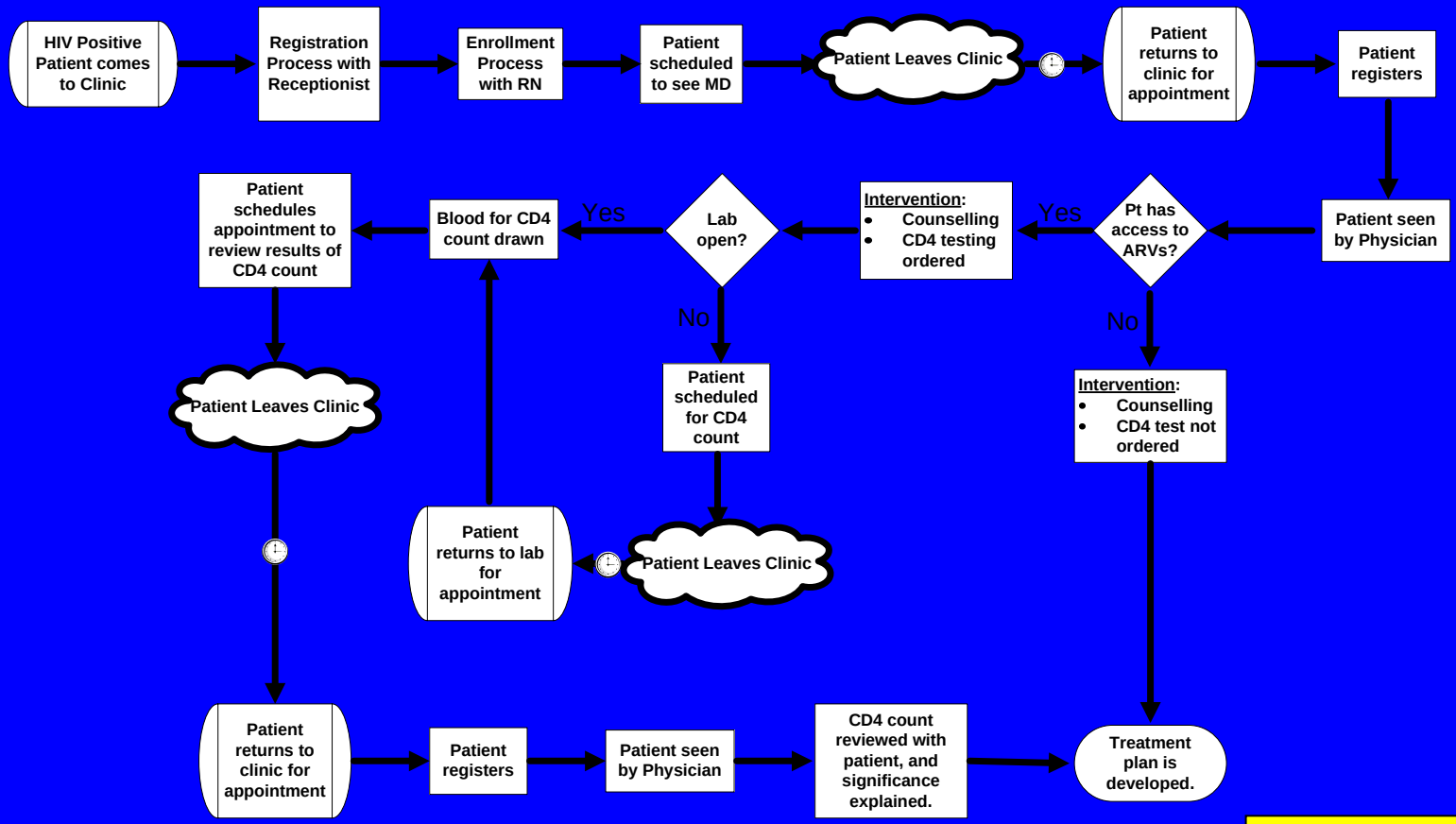
Integrated Health Network Model



Health programs are complex systems



Workflow model: obtaining a CD4



Complex and interdependent

Core principle of OR #2: Actively try to make the program better

- Better "understanding" of situation is not enough
- Better can mean…
  - Improve access to services
  - Improve quality
  - Limit costs (find cost-effective strategies)
  - Improve health

Core principle of OR #3: Use results to improve program

- Using results can mean…
  - Implement new strategy on local / national scale
  - Influence national / international policy
  - Dissemination of results, develop “best practices”

➢ OR successful only if results used to improve the program

  ➢ Published papers are NOT a valid indicator of OR success

Corollary: OR requires collaboration between managers and researchers

- Program managers/policy-makers
  - Should be involved in ALL ASPECTS of research process
    - Understand health care system
    - Help ensure problem is important, solution is feasible
    - Help ensure results will be implemented
- Researchers
  - Understand of research methodology
  - Responsible of recommending and implementing appropriate research techniques
- Can be the same person

How is OR different from other types of research?

- All types of health research try to improve health
- All types of research can use similar methodologies
  - Quantitative, qualitative, surveys, experiments, focus groups, simulations

- Difference = focus and goals

Classification of different types of research

A classification of health research Based on the application of biological social and behavioural sciences methods		
Objects of Analysis		
Level of Analysis	**Health problems/conditions**	**Health Care Responses**
Individual or Subindividual	Biomedical research - biological processess - body structure and functions - pathological mechanisms	Clinical research - efficacy of ppreventive diagnostic and therapeutic procedures eg: drug efficacy and side effects - natural history of diseases
Population- Public Health Research	Epidemiological Research - frequency distribution and causes of diseases	Health Systems Research - policy research - operational research

Adapted from Julio Frenk "The new Public Health" in Annual Review of Public Health 1993 14:469-90

Example: Research in Syphilis

- **Biomedical research:** effects of syphilis infection on the human body, fetus or on life cycle of the micro-organism
- **Clinical research**: efficacy of various treatments for syphilis, such as long-acting penicillin injections and vaccines
- **Epidemiological research:** numbers/proportions of people suffering from syphilis & risk factors determining the distribution of the disease
- **Health systems research:** examines health system function to measure how screening or treatment for syphilis is delivered.
  For example, it helps to find out why so many pregnant women who have syphilis are inadequately treated and deliver newborn babies that are infected.
- **Operations research:** may be similar to HSR, but implements new programmatic strategy to determine if more women can be treated for syphilis→ strategy rolled-out to other sites if effective

OR overlaps with other types of research

- Health services/systems research
- Implementation science
- Translational research
- Quality improvement
- Policy and economic analysis

- Difficult to define OR in exclusion of other types of research

Broad methodologies of OR

- Modeling (classic)
  - Develop mathematical model to mimic health care system
    - Manipulate to find the best possible “solution”
      - Optimize efficiency
      - Maximize X given constraints Y
- Intervention-based (Population Council)
  - Design/test best way to deliver services
  - Similarities to quality improvement (IHI/WHO)

Example of OR modeling in HIV

- SIMCLIN computer model*
  - Consortium for Strategic HIV Operations Research (Clinton AIDS Initiative)
  - Goals
    - Plan best allocation of current resources
    - Forecast future needs
    - Predict impact of program changes
  - Examples of use:
    - Given X nurses and Y doctors, how many patients can be treated in 1 year with ARVs?
    - How many nurses and doctors are needed to treat 1,000 patients per year?
    - How will spacing CD4 schedule affect resource needs?

* Clinton Foundation HIV/AIDS Initiative, Consortium for Strategic HIV Operations Research (CSHOR): SIMCLIN- An HIV Service Delivery Resource Planning Tool Technical Overview, available online at http://www.cshor.org/SIMCLINTechnicalOverview.doc

Inputs to model

Adults ON ARVs

Nurse	On1st Visit?	☑	2nd?	☑	On weeks:	0, 2, 4	and every 4	weeks thereafter
Physician	On1st Visit?	☑	2nd?	☑	On weeks:	0, 2, 4	and every 4	weeks thereafter
Clerk	On1st Visit?	☑	2nd?	☑	On weeks:	0, 2, 4	and every 4	weeks thereafter
Counselor	On1st Visit?	☑	2nd?	☑	On weeks:	0, 2, 4	and every 4	weeks thereafter

Adults in care — If CD4 count < 350

Nurse	On1st Visit?	☑	2nd?	☑	On weeks:	24	and every 24	weeks thereafter
Low CD4	On1st Visit?	☑	2nd?	☑	On weeks:	12	and every 12	weeks thereafter
Physician	On1st Visit?	☑	2nd?	☑	On weeks:	24	and every 24	weeks thereafter
Low CD4	On1st Visit?	☑	2nd?	☑	On weeks:	12	and every 12	weeks thereafter
Clerk	On1st Visit?	☑	2nd?	☑	On weeks:	24	and every 24	weeks thereafter
Low CD4	On1st Visit?	☑	2nd?	☑	On weeks:	12	and every 12	weeks thereafter
Counselor	On1st Visit?	☑	2nd?	☑	On weeks:	24	and every 24	weeks thereafter
Low CD4	On1st Visit?	☑	2nd?	☑	On weeks:	12	and every 12	weeks thereafter

Risk of toxicity leading to drug switch

Data format:

D4T		AZT		NVP		EFV	
CUMULATIVE ANNUAL RATES		CUMULATIVE ANNUAL RATES		CUMULATIVE ANNUAL RATES		CUMULATIVE ANNUAL RATES	
Year 1	0.0469	Year 1	0.0237	Year 1	0.0441	Year 1	0.0102
Year 2	0.1026	Year 2	0.047	Year 2	0.0668	Year 2	0.0196
MONTHLY RATES		MONTHLY RATES		MONTHLY RATES		MONTHLY RATES	
Month 1	0.0000	Month 1	0.0000	Month 1	0.0000	Month 1	0.0000
Month 2	0.0000	Month 2	0.0000	Month 2	0.0000	Month 2	0.0000
Month 3	0.0000	Month 3	0.0000	Month 3	0.0000	Month 3	0.0000
Month 4	0.0000	Month 4	0.0000	Month 4	0.0000	Month 4	0.0000
Month 5	0.0000	Month 5	0.0000	Month 5	0.0000	Month 5	0.0000
Month 6	0.0000	Month 6	0.0000	Month 6	0.0000	Month 6	0.0000
Month 7	0.0000	Month 7	0.0000	Month 7	0.0000	Month 7	0.0000
Month 8	0.0000	Month 8	0.0000	Month 8	0.0000	Month 8	0.0000
Month 9	0.0000	Month 9	0.0000	Month 9	0.0000	Month 9	0.0000
Month 10	0.0000	Month 10	0.0000	Month 10	0.0000	Month 10	0.0000
Month 11	0.0000	Month 11	0.0000	Month 11	0.0000	Month 11	0.0000
Month 12	0.0000	Month 12	0.0000	Month 12	0.0000	Month 12	0.0000
Month 13	0.0000	Month 13	0.0000	Month 13	0.0000	Month 13	0.0000
Month 14	0.0000	Month 14	0.0000	Month 14	0.0000	Month 14	0.0000
Month 15	0.0000	Month 15	0.0000	Month 15	0.0000	Month 15	0.0000
Month 16	0.0000	Month 16	0.0000	Month 16	0.0000	Month 16	0.0000
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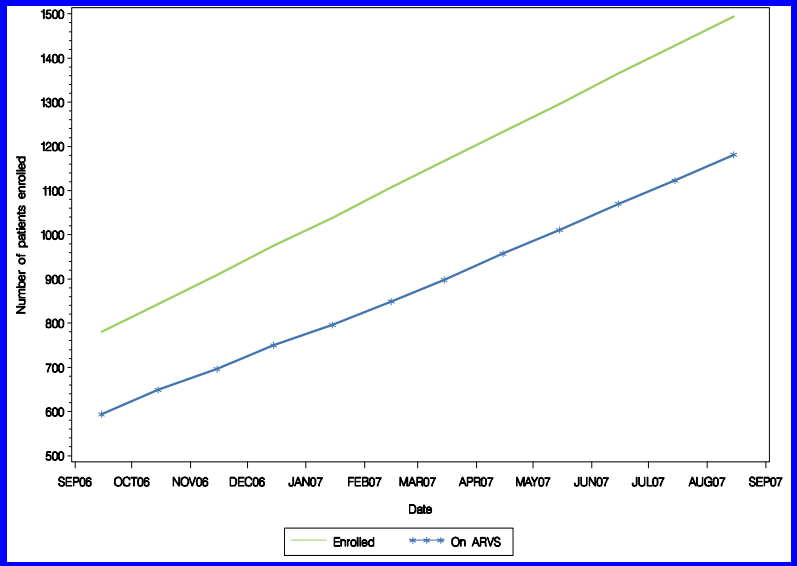
Month 19	0.0000	Month 19	0.0000	Month 19	0.0000	Month 19	0.0000
Month 20	0.0000	Month 20	0.0000	Month 20	0.0000	Month 20	0.0000
Month 21	0.0000	Month 21	0.0000	Month 21	0.0000	Month 21	0.0000
Month 22	0.0000	Month 22	0.0000	Month 22	0.0000	Month 22	0.0000
Month 23	0.0000	Month 23	0.0000	Month 23	0.0000	Month 23	0.0000
Month 24+	0.0000	Month 24+	0.0000	Month 24+	0.0000	Month 24+	0.0000

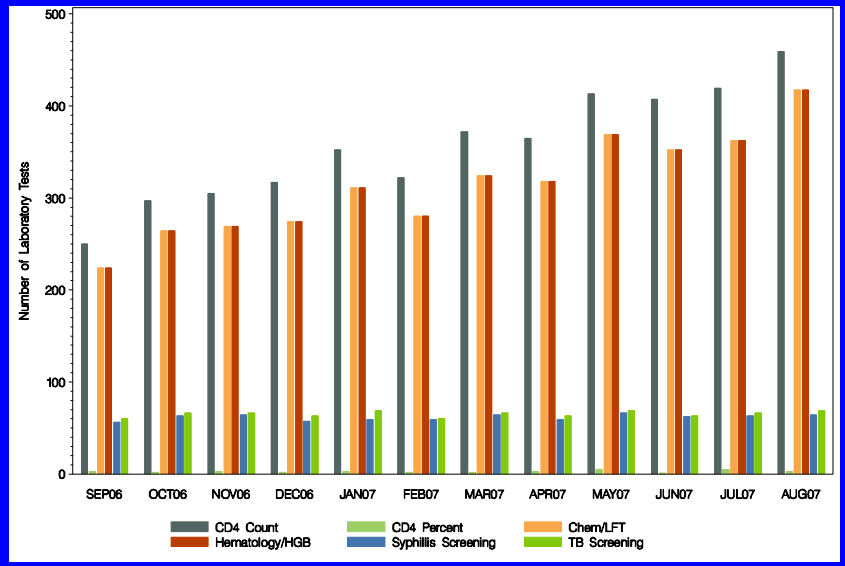
Risk of patient death during follow-up

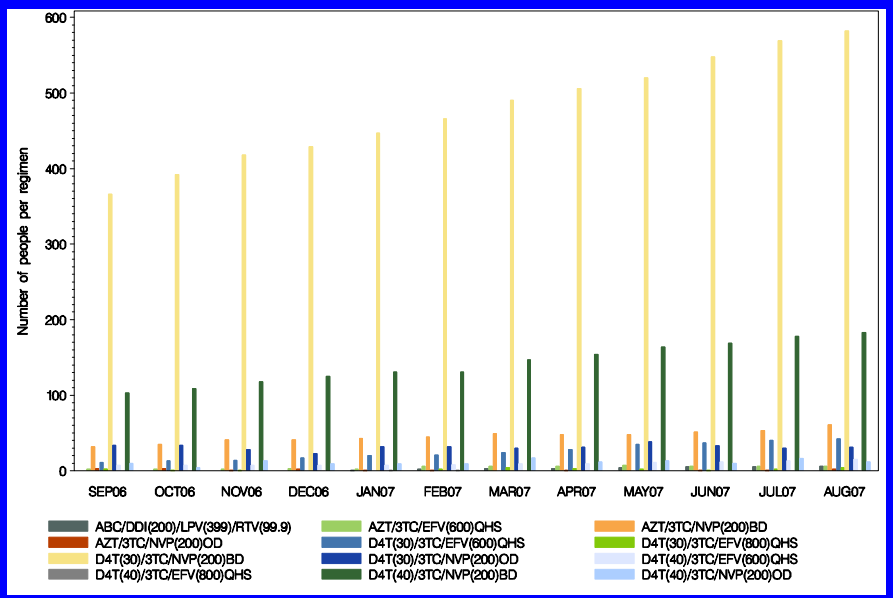
Data format: Annual

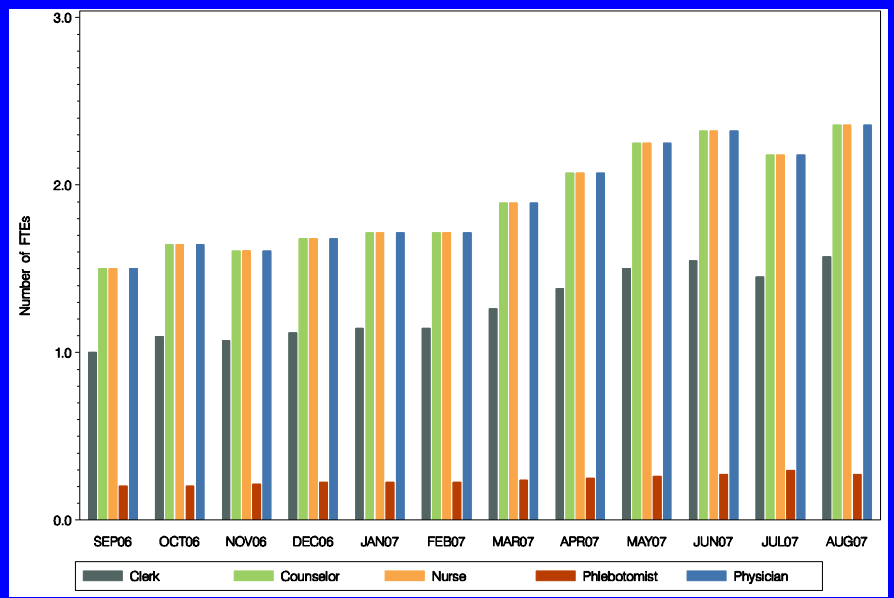
Risk of death for each month on treatment For patients on ARVs				Risk of death for each month in clinic care For patients NOT on ARVs			
CUMULATIVE ANNUAL RATES				CUMULATIVE ANNUAL RATES			
Year 1:	0.1500	Year 2:	0.1700	Year 1:	0.2000	Year 2:	0.2400
MONTHLY RATES				MONTHLY RATES			
Month 1	0.0134	Month 13	0.0019	Month 1	0.0184	Month 13	0.0042
Month 2	0.0134	Month 14	0.0019	Month 2	0.0184	Month 14	0.0042
Month 3	0.0134	Month 15	0.0019	Month 3	0.0184	Month 15	0.0042
Month 4	0.0134	Month 16	0.0019	Month 4	0.0184	Month 16	0.0042
Month 5	0.0134	Month 17	0.0019	Month 5	0.0184	Month 17	0.0042
Month 6	0.0134	Month 18	0.0019	Month 6	0.0184	Month 18	0.0042
Month 7	0.0134	Month 19	0.0019	Month 7	0.0184	Month 19	0.0042
Month 8	0.0134	Month 20	0.0019	Month 8	0.0184	Month 20	0.0042
Month 9	0.0134	Month 21	0.0019	Month 9	0.0184	Month 21	0.0042
Month 10	0.0134	Month 22	0.0019	Month 10	0.0184	Month 22	0.0042
Month 11	0.0134	Month 23	0.0019	Month 11	0.0184	Month 23	0.0042
Month 12	0.0134	Month 24+	0.0019	Month 12	0.0184	Month 24+	0.0042

Outputs of model







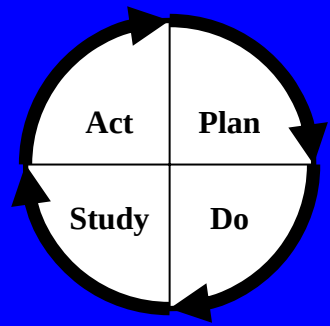


Other uses of modeling

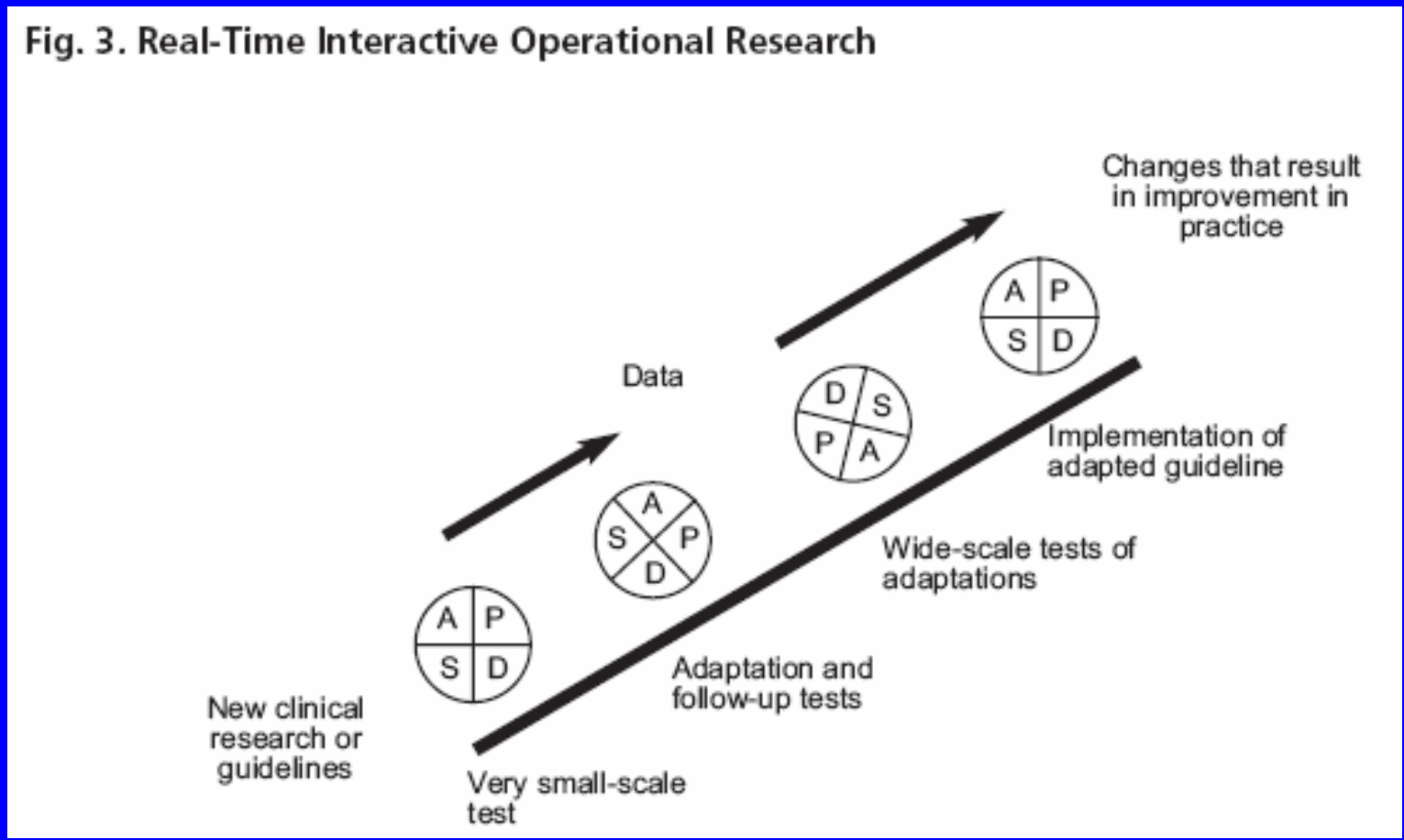
- Improving efficiency of resource allocation given certain constraints
  - Where to place HIV treatment facilities, given HIV prevalence and infrastructure, human resource, and transportation constraints
  - Where to locate laboratory facilities, given technology and transportation constraints
  - How to improve clinic efficiency, given human resource and infrastructural constraints

Intervention-based OR

Population Council	**IHI Collaborative**
Linear	***Cyclical***
1. Identify program problem	1. Plan
2. Generate program solution	2. Do
3. Test program solution	3. Study
4. Use/disseminate results	4. Act



Real-Time Interactive Operations Research (IHI/WHO)



From: An Approach to Rapid Scale-up: Using HIV/AIDS Treatment and Care as an Example. WHO, 2004.

Steps in intervention-based OR

1. Identify program problem
   - Usually determined in ongoing program
   - Routine data (M&E, surveillance) vs. program evaluation
   - Under control of program manager

Quantitative (+/- qualitative)

2. Generate program solution
   - Review workflow, talk to staff/clients
   - Consider exploratory study if causes/solution unknown
   - Must be feasible

Quantitative or qualitative

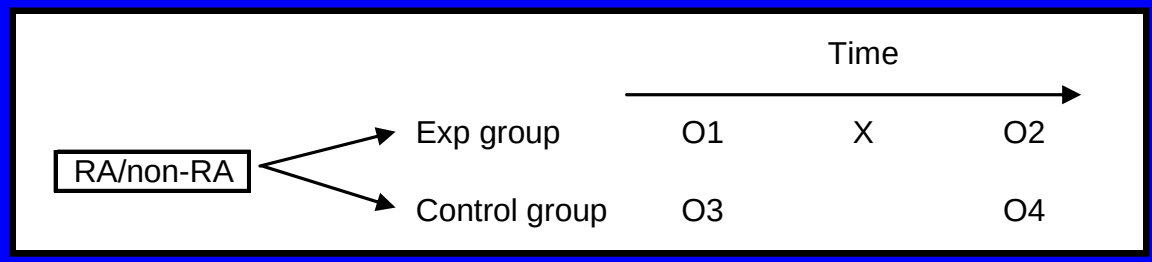
3. Test program solution
   - Level of intervention: facility vs. individual
   - Data measurement: routine vs. added procedures
   - Allocation: non-randomized (quasi-experimental) vs. randomized (experimental)
   - Design choice dependent on: resources, time, consequence of “wrong” answer

Quantitative (+/- qualitative)

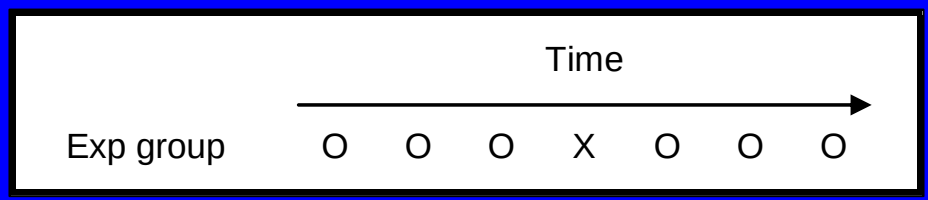
4. Use/disseminate results
   - Continue/expand successful interventions
   - Influence national/international policy
   - Not typically “generalizable” but can be relevant for similar programs (“best practices”)

Common OR study designs (Experimental/quasi-experimental)

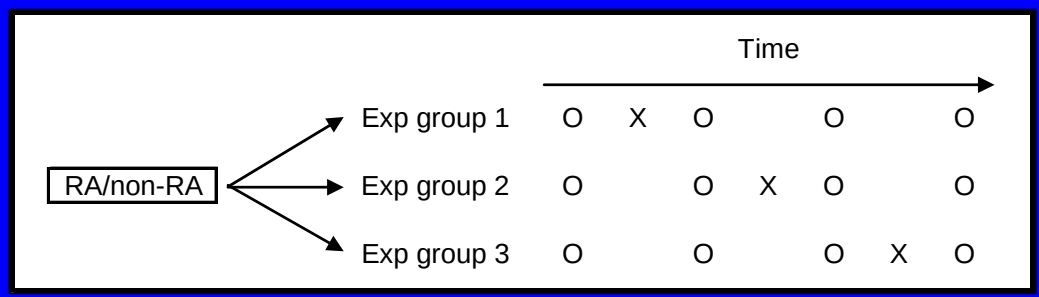
Pre-post control /non-equivalent control group



Simple time-series (some control for time)



Step-wedge time-series (better control for time)



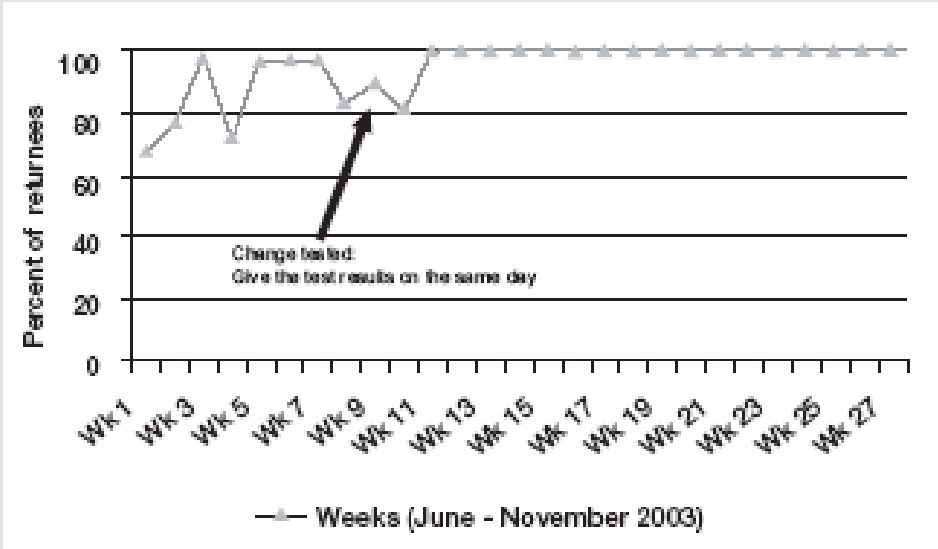
Example 1: HIV testing in pMTCT program in Rwanda

Problem: 2-3 day delay in getting HIV test results → 18% did not return for results

Potential solution: Same-day results

Test of solution: Time series, dropout ~0 post-intervention

Fig. 4. Return rates for test results among women tested in Rwanda's Byumba Health Center, PMTCT Service

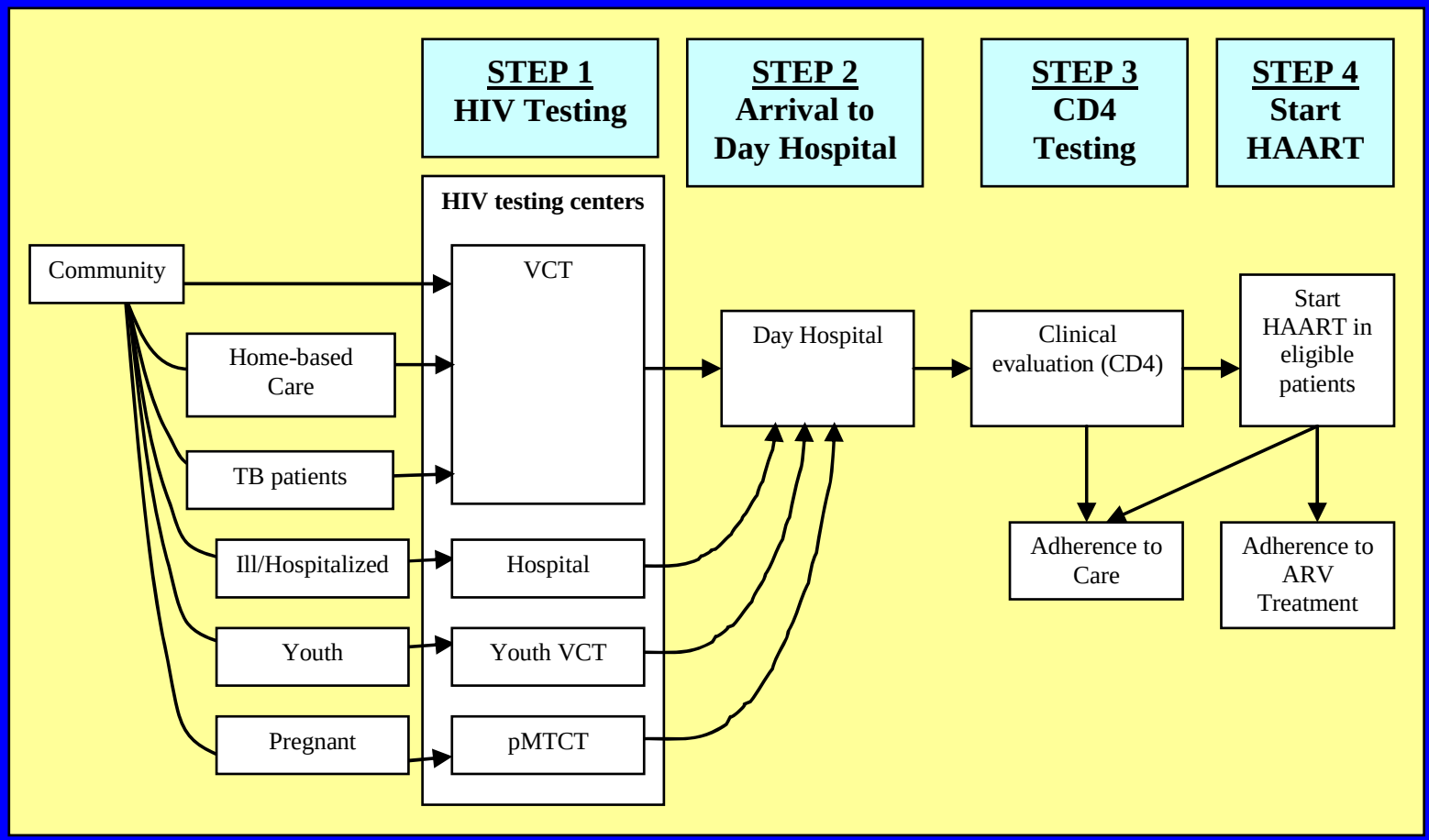


Source: PMTCT Collaborative, Rwanda, work implemented by the Government of Rwanda with technical assistance from the United States Agency for International Development (USAID) funded Quality Assurance Project - University Research Co. LLC

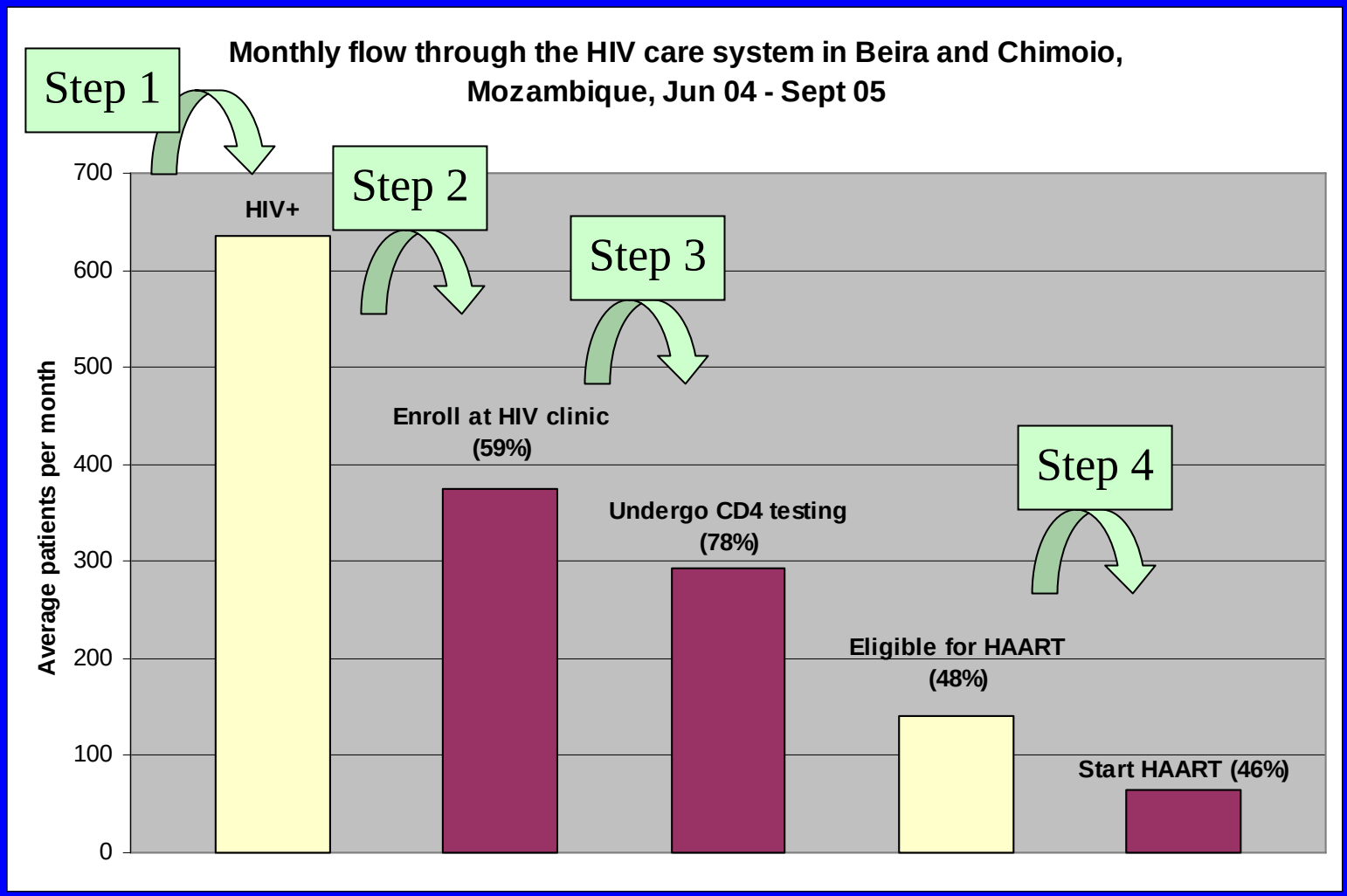
Source: An Approach to Rapid Scale-up: Using HIV/AIDS Treatment and Care as an Example. WHO. Geneva, 2004.

Example 2: How to increase the number of patients who start HAART?

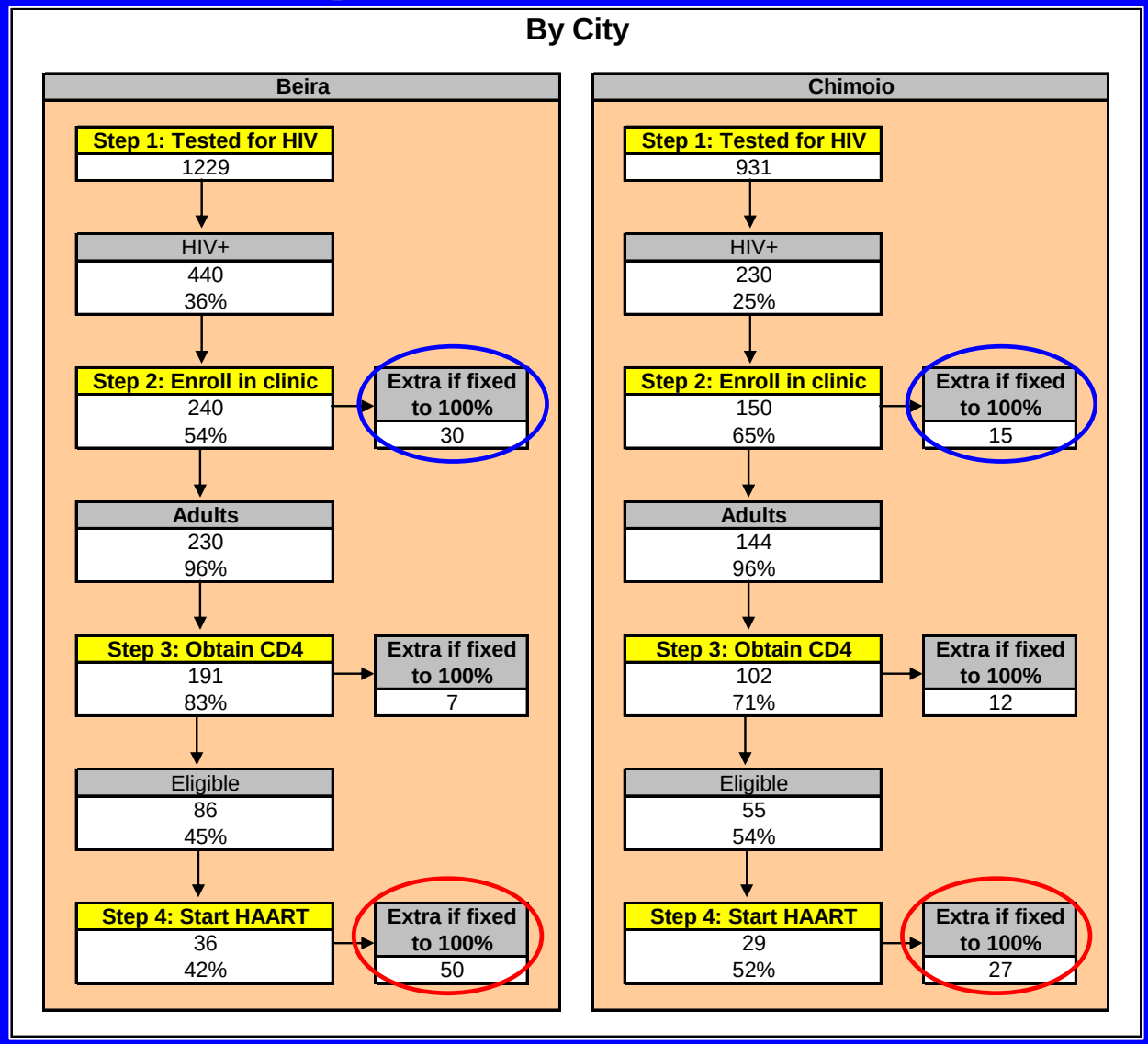
- Identify the steps (workflow) in the health system



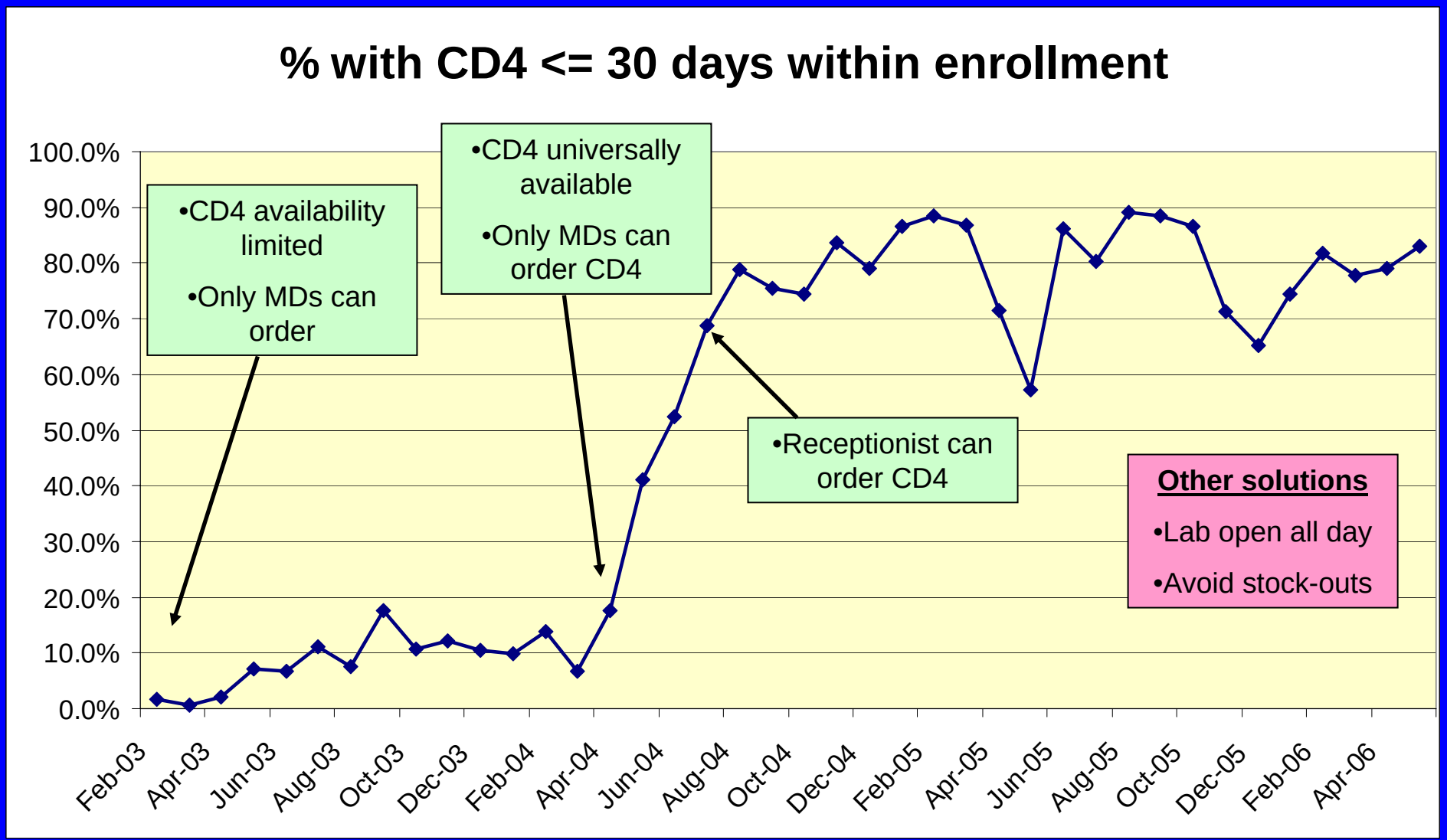
Using programmatic data: Where are patients lost?



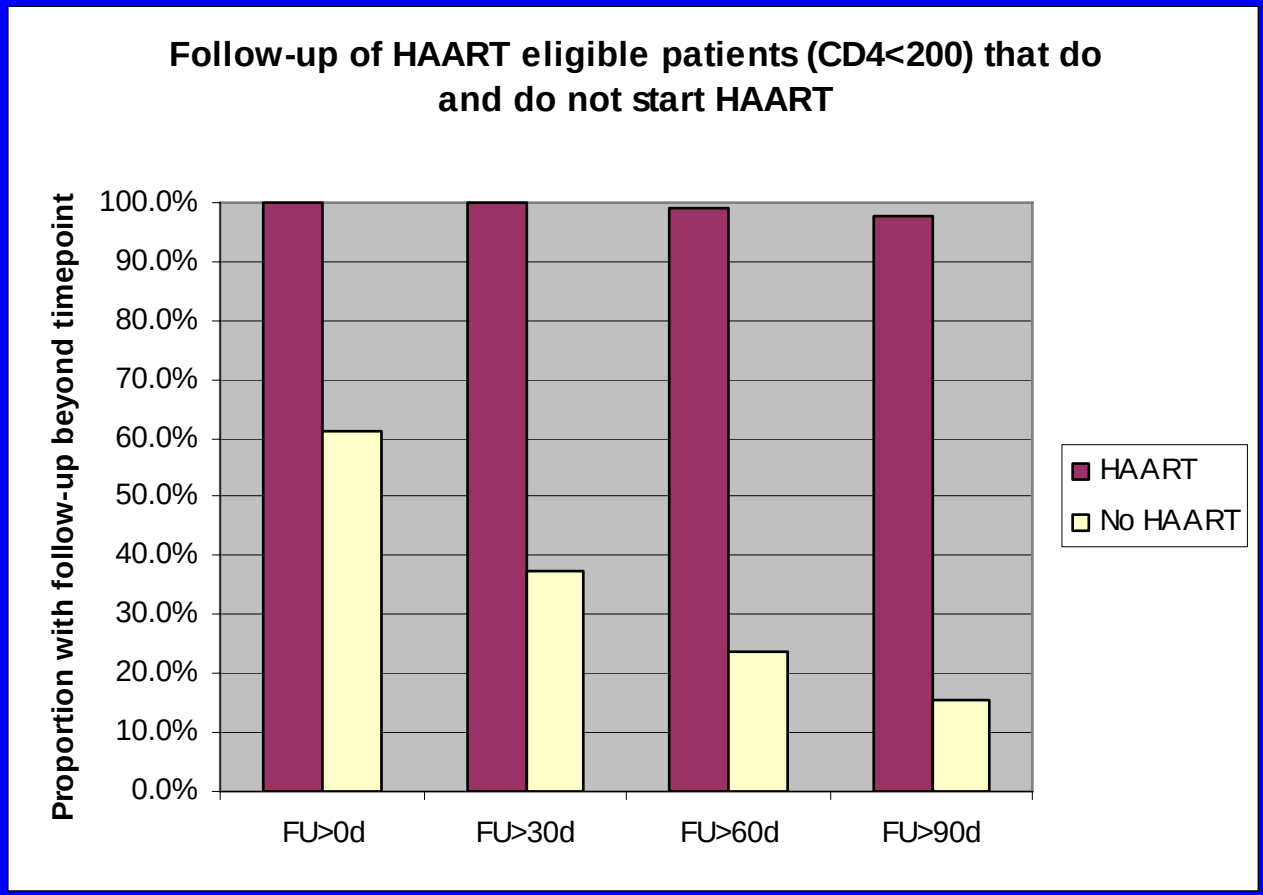
Using programmatic data: What are priorities to address?



Improving rates of CD4 testing (Step 3)



Why do HAART-eligible patients not start ARVs (step 4)?



- Poor follow-up also reported as reason for not starting HAART in other studies
  - *Giordano TP et al, Factors Associated with the Use of Highly Active Antiretroviral Therapy in Patients Newly Entering Care in an Urban Clinic. JAIDS, 32:399-405.*

Improving rates of starting ARVs in HAART-eligible patients

- Reasons for poor follow-up
  - Pre-HAART procedure too cumbersome
  - Dissatisfaction with services
  - Trouble paying transportation costs
  - Poor understanding of clinic procedures
  - Stigma of going to HIV clinic
  - Death

- Potential solutions
  - Change workflow around HAART-eligible patients
  - Improve counseling
  - Improve relationship between patients and health care workers
  - Decentralize ARV services

Other examples of OR

Program problem	Potential OR studies (Pre-post control, time series, step-wedge)
Poor adherence to HAART	Study strategies to improve adherence (DOT, counseling, community-based treatment partners, food/transport subsidies)
Low rates of HIV treatment among TB patients, inpatients	Study integration of HIV services into TB programs or hospital services
Underdiagnosis of TB among HIV+ patients	Study strategies to increase TB screening/diagnosis (training/mentorship, standardized care algorithms, screen at VCT)
Low rates of HIV treatment among pregnant women	Study strategies to improve retention into care (decentralize HIV services, improve counseling, involvement of peer counselors)
Poor provider adherence to HIV care protocols	Study strategies to improve adherence to protocols (training/mentorship, performance reviews, involvement of lower-level HCWs)
Low level of prevention behaviors among HIV+ people	Study strategies to increase prevention (couples counseling/care, intensify prevention counseling in testing and care centers)

OR resources

- Designing HIV/AIDS Intervention Studies: An Operations Research Handbook. Andrew A. Fisher and James Foreit. The Population Council, New York, 2002. Available at: http://www.popcouncil.org/pdfs/horizons/orhivaidshndbk.pdf

- An Approach to Rapid Scale-up: Using HIV/AIDS Treatment and Care as an Example. World Health Organization, Geneva, 2004. Available at: http://www.who.int/entity/hiv/pub/prev_care/en/rapidscale_up.pdf

- The Breakthrough Series: IHI's Collaborative Model for Achieving Breakthrough Improvement. Institute for Health Care Improvement. Cambridge, MA, 2003. Available at http://www.ihi.org/NR/rdonlyres/BCA88D8F-35EE-4251-BB93-E2252619A06D/0/BreakthroughSeriesWhitePaper2003.pdf

- Population Council / Horizons program on HIV/AIDS OR: http://www.popcouncil.org/horizons/

Thank you