Yale SCHOOL *of* MANAGEMENT

YALE UNIVERSITY
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Operations Research and Public Health

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What Is Operations Research?

- Operations research is the scientific study of operations for the purpose of making better decisions
- Also refers to mathematical techniques developed/used by operations researchers
- Original applications were military; now prevalent in supply chain management, transportation, private/public services, homeland security/counterterrorism, etc.

What Is Public Health?

- The mission of public health is to assure conditions in which people can be healthy!
- Mission is accomplished via the application of public health *science* to the design and operation of public health *services*
- Operations research (and management) principles and techniques can be applied in both of these areas

Public Health Operations

- disease screening/surveillance (e.g. HIV, influenza)
- outbreak investigation (e.g. SARS)
- vaccination (e.g. childhood diseases), quarantine/isolation (e.g. TB)
- behavioral modification programs (e.g. STDs)
- inspection/standards enforcement at public establishments (e.g. restaurants)
- environmental monitoring (e.g. bacterial levels at public swimming areas)
- vector control (e.g. mosquitos, ticks, etc.)

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OPERATIONS RESEARCH AND PUBLIC HEALTH

THE problem of translating theory into practice is usually beset with difficulty, even in the more exact natural sciences. In the past, this problem has suffered from neglect, perhaps because it was assumed that practical men could apply in practice any clearly stated theory, and needed no special agency to facilitate and accelerate this process.

Following the termination of hostilities, it was quickly realized that operations research methods and technics could have wide application to conditions and needs of peace in government, industry, and in the community in general.[4] Since the war

Clearly, here are exciting possibilities of interweaving theoretical insight with practical experience which no health worker can afford to overlook. While the

How valuable operations research will eventually be to public health remains to be seen. The surface of the problems presented by such interaction of research and policy decisions has barely been touched. All that can be done here is to draw attention to this important branch of scientific activity and to indicate its possible potential for public health.

Operations Research and Epidemiology

- What is the most famous equation in service operations management?

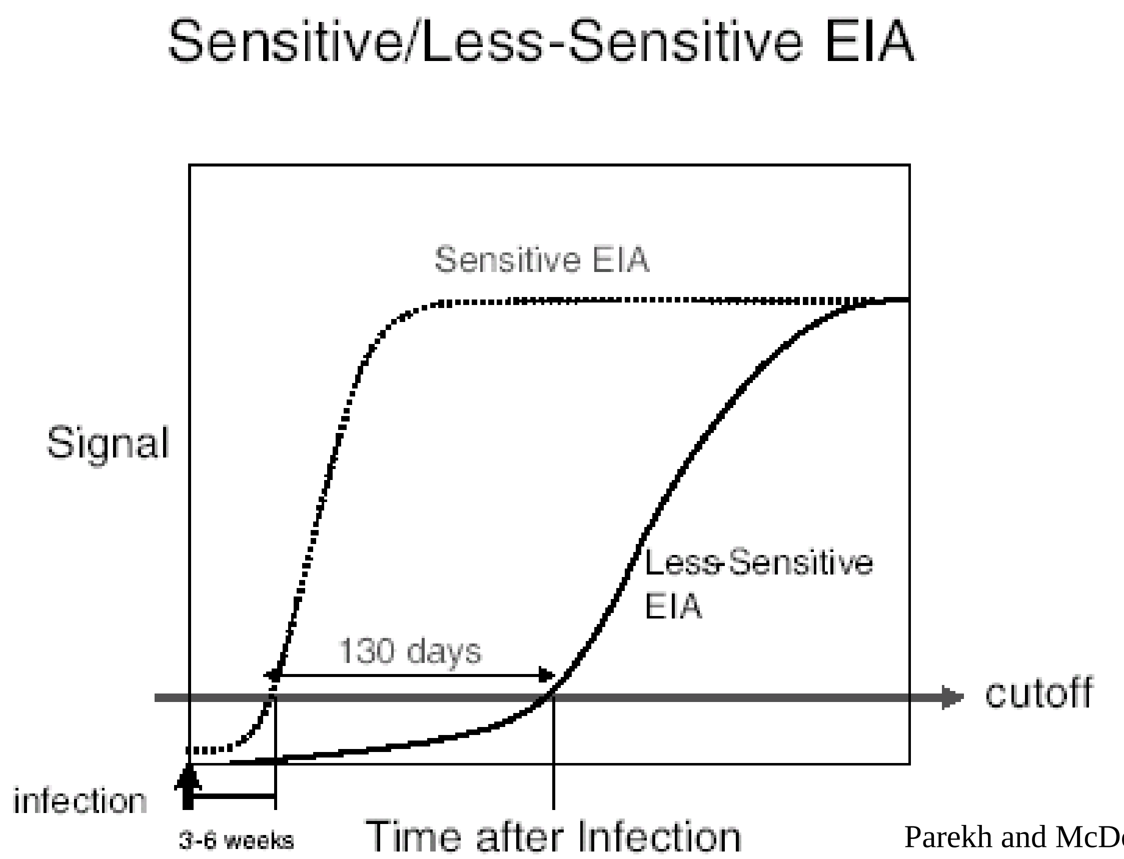
$$L = \lambda W$$

- What is the most famous equation in epidemiology?

Prevalence = Incidence x Duration

- Any questions?

Application of $L = \lambda W$: Estimating HIV Incidence



Parekh and McDougal, *AIDS Rev* 2001;3:183-193

Figure 4. *A: Comparison of sensitive (3A11) and less-sensitive (3A11-LS) EIAs. B: Sensitive EIA plateaus soon after seroconversion, while less-sensitive EIA has longer dynamic range and takes about an additional 130 days to register reactive.*

Table 1. Estimated Incidence of Human Immunodeficiency Virus Infection, 50 US States and the District of Columbia

Characteristic	Stratified Extrapolation Approach: 22 States, No. (%)[a] BED Tested[b]	2006 Diagnoses[c]	2006 Incidence	50 States + DC, 2006 Incidence, No. (%) [95% CI][d]	Extended Back-Calculation Approach, 50 States + DC, Incidence per Year, 2003-2006, No. (%) [95% CI][d]
Total	6864	39 400	40 800	56 300 [48 200-64 500]	55 400 [50 000-60 800]
Sex					
Male	4892 (71)	28 900 (73)	29 300 (72)	41 400 (73) [35 100-47 700]	42 000 (76) [37 400-46 600]
Female	1972 (29)	10 600 (27)	11 500 (28)	15 000 (27) [12 600-17 300]	13 400 (24) [11 000-15 800]
Race/ethnicity[e]					
White	1707 (25)	11 400 (29)	13 100 (33)	19 600 (35) [16 400-22 800]	17 700 (32) [14 700-20 700]
Black	3825 (56)	20 000 (51)	19 600 (49)	24 900 (45) [21 100-28 700]	27 800 (50) [24 200-31 400]
Hispanic	1190 (17)	7000 (18)	6800 (17)	9700 (17) [7900-11 600]	8600 (16) [6200-11 000]
Asian/Pacific Islander	78 (1)	440 (1)	590 (1)	1200 (2) [490-1900]	1000 (2) [200-1800]
American Indian/ Alaska Native	21 (<1)	130 (<1)	180 (<1)	290 (1) [60-500]	300 (<1) [50-700]
Age, y					
13-29	2790 (41)	13 100 (33)	14 100 (35)	19 200 (34) [16 300-22 200]	21 200 (38) [17 000-25 400]
30-39	1892 (28)	12 100 (31)	12 500 (31)	17 400 (31) [14 600-20 200]	16 800 (30) [13 600-20 000]
40-49	1539 (22)	9800 (25)	9900 (24)	13 900 (25) [11 700-16 100]	12 300 (22) [9100-15 500]
50-99	643 (9)	4400 (11)	4300 (11)	5800 (10) [4600-7100]	5100 (9) [2900-7300]
Transmission category					
MSM	3582 (52)	18 400 (48)	20 100 (51)	28 700 (53) [24 300-33 100]	31 200 (56) [25 400-37 000]
IDU	749 (11)	5600 (15)	4900 (12)	6600 (12) [5300-7900]	5900 (11) [3500-8300]
MSM/IDU	182 (3)	1200 (3)	1400 (3)	2100 (4) [1500-2700]	1600 (3) [400-2800]
Heterosexual	2328 (34)	13 100 (34)	13 100 (33)	16 800 (31) [14 200-19 400]	16 400 (30) [12 600-20 200]

Abbreviations: BED, BED human immunodeficiency virus 1 capture enzyme immunoassay; CI, confidence interval; IDU, injection drug use; MSM, men who have sex with men.
[a] Alabama, Arizona, Colorado, Connecticut, Florida, Georgia, Illinois, Indiana, Louisiana, Michigan, Mississippi, Missouri, New Jersey, New York, North Carolina, Oklahoma, Pennsylvania, South Carolina, Tennessee, Texas, Virginia, Washington.
[b] Numbers do not count individuals diagnosed with AIDS at or within 6 mo after human immunodeficiency virus diagnosis; these were risk redistributed but not adjusted for reporting delay.
[c] Numbers for 2006 diagnoses were adjusted for reporting delay and risk redistribution.
[d] Confidence intervals reflect random variability affecting model uncertainty but may not reflect model-assumption uncertainty; thus, they should be interpreted with caution.
[e] Race/ethnicity and transmission category subgroup numbers may not sum to the overall total because cases with unknown race/ethnicity or unknown transmission categories are excluded. However, percentages are adjusted for the exclusion and sum to 100%.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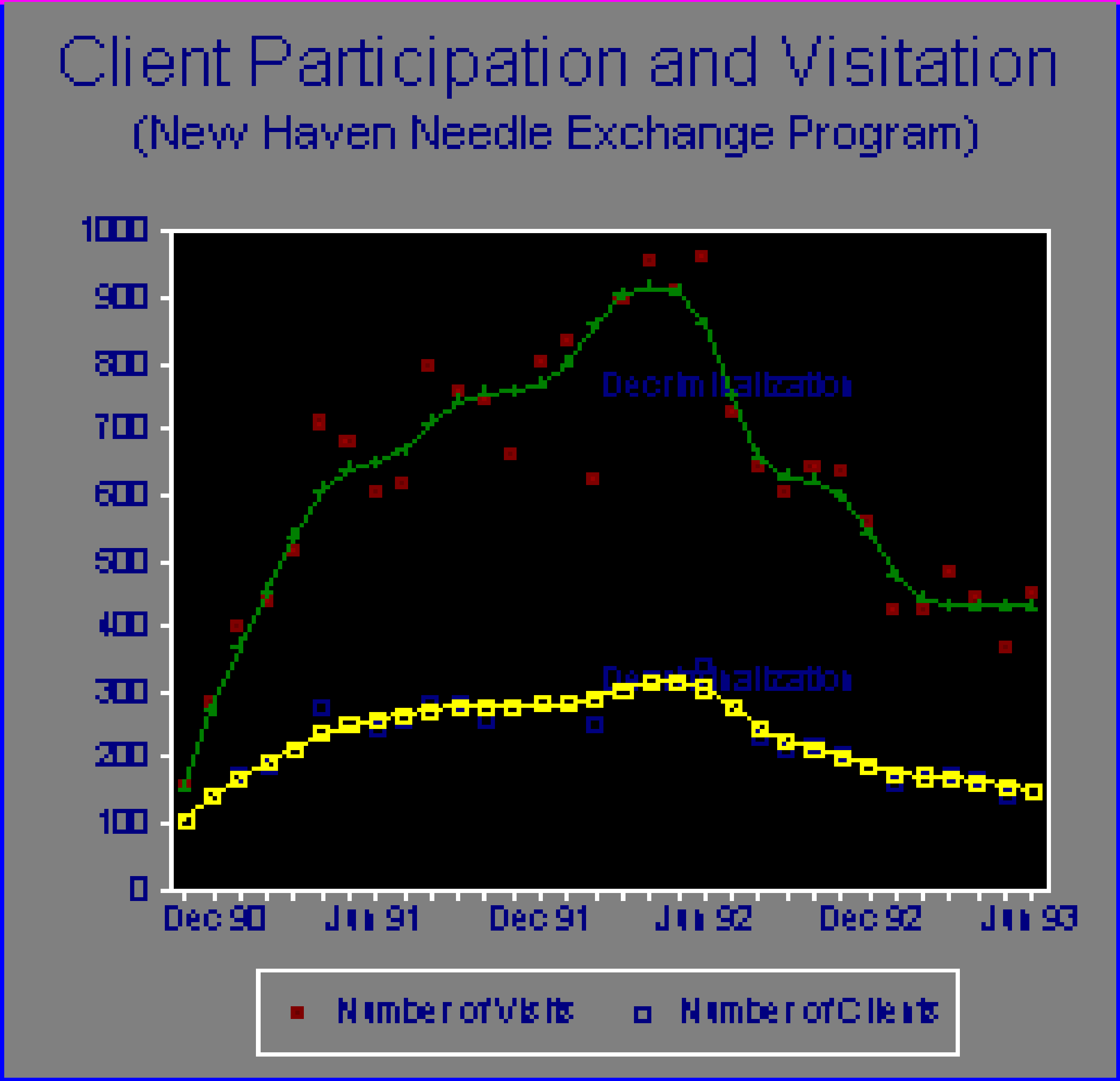
OR Approach to Needle Exchange

- needle exchange reduces needle circulation times
- as a consequence, *needles share fewer people*
- as a further consequence, *fraction of needles that are infected should decline*
- easy to capture this logic with simple model
- what was not so easy was to verify it with actual data from the needle exchange program

Circulation Theory: An Operational Model



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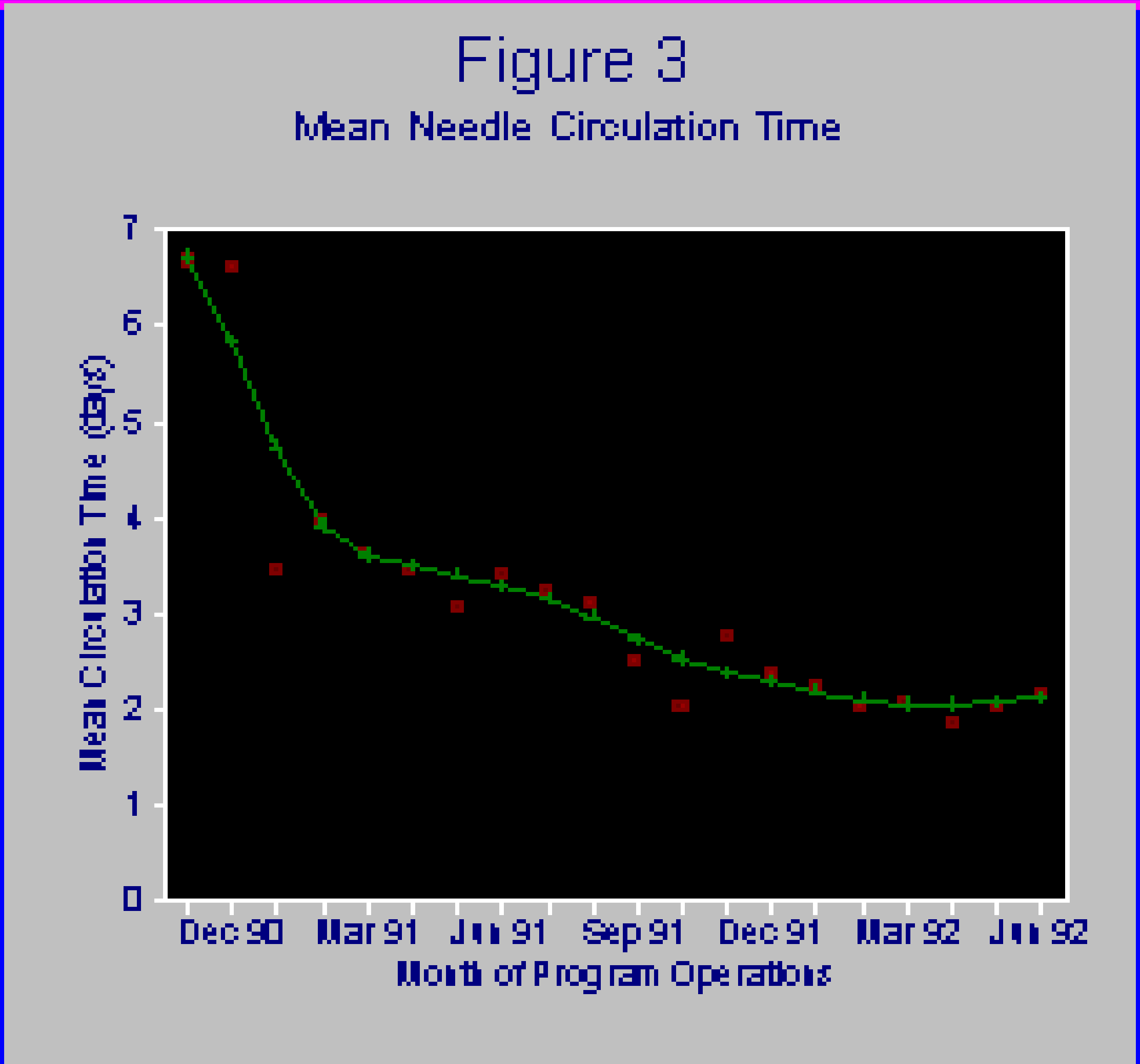

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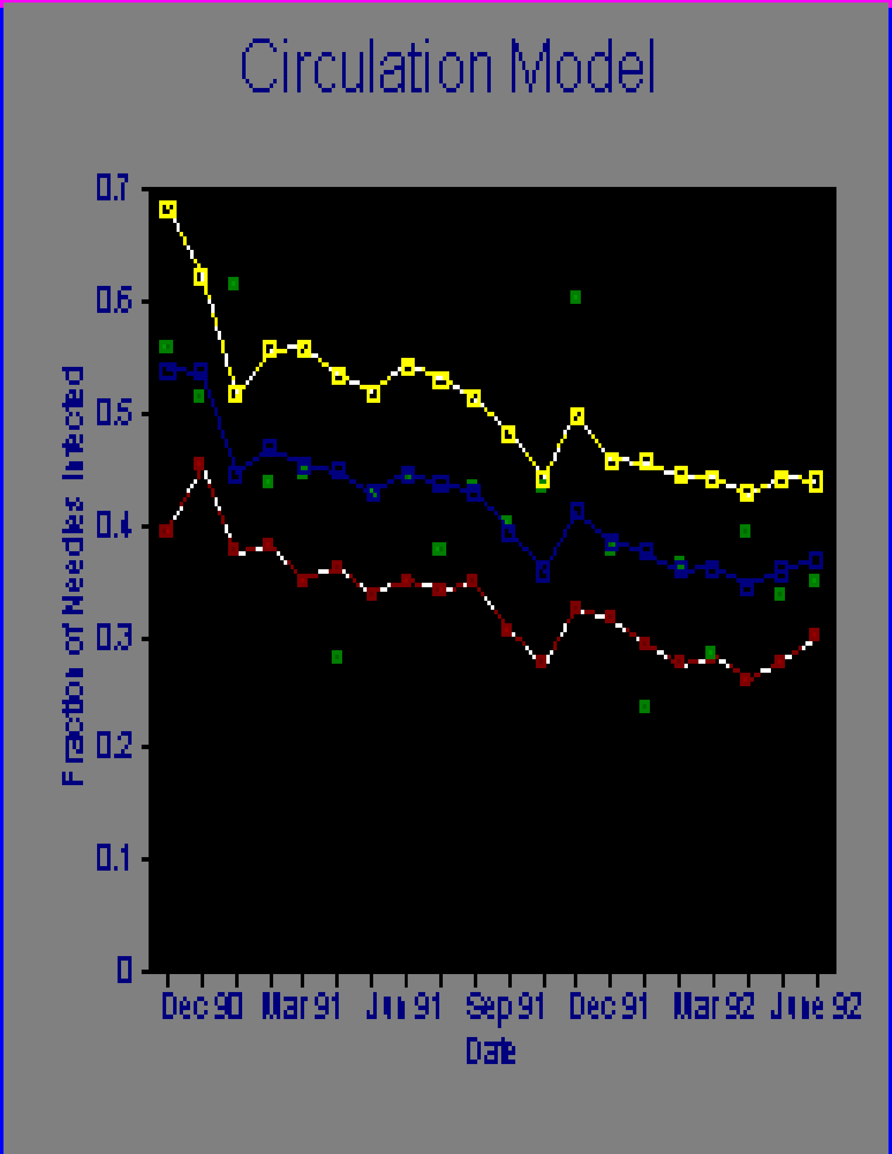

Summary

- There are many outstanding opportunities to apply operations research ideas to improve public health
  - methodological contributions to epidemiology
  - practical contributions to the design, evaluation and operation of public health activities