
EMORY
ROLLINS
SCHOOL OF
PUBLIC
HEALTH
Defining Vaccine Effects
Session 6a

Outline

1. Mechanisms of vaccine protection
    a. Against
        - Infection
        - Disease
        - Infectiousness
    b. Leaky or all-or-nothing
2. Types of vaccine effects

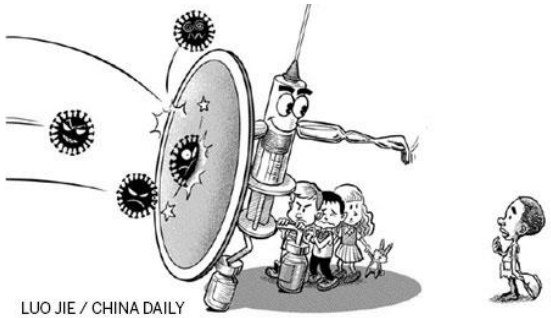
Vaccine efficacy measures…

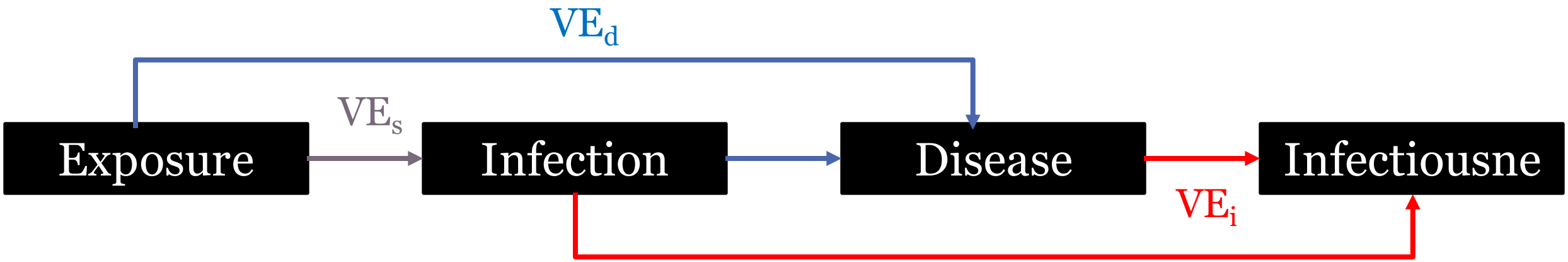
Typically VE refers to "**Vaccine Efficacy for Susceptibility**"

- Against infection (VE_s)
- Against disease (VE_d)

"**Vaccine Efficacy for Infectiousness**" (VE_i)

- The per-contact transmission probability ***FROM*** infected vaccinated people compared to infected un-vaccinated people





VE$_s$: protection against infection
VE$_d$: protection against disease
VE$_i$: protection against infectiousness

Protection against infection or disease?

	Inactivated Polio Vaccine (IPV)	Oral Polio Vaccine (OPV)
Developed	1955 by Jonas Salk	1950s by Albert Sabin
Formulation	Killed, injectable	Live, oral
Serotypes	3 serotypes	1,2 or 3 serotype
Protective immunity	Excellent	Excellent
Mucosal immunity	Little -> wild virus can still multiply in the intestines and be shed in the feces, risking continued circulation	Excellent -> so effective at interrupting transmission of the virus

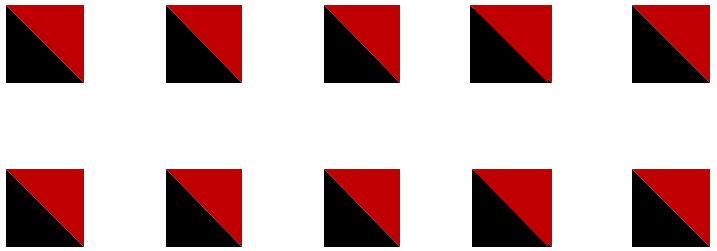
The mainstay of global eradication

Mechanisms of vaccination

Leaky immune protection

Also known as degree-type or partial protection

partially reduce susceptibility to infection for all vaccinated individuals

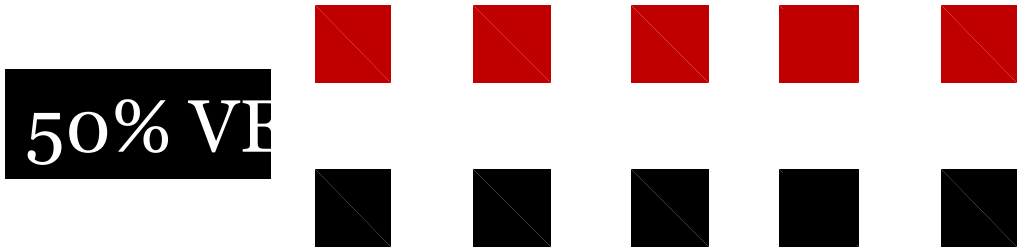


No correlate of protection

All-or-nothing immune protection

Also known as take-type

confer complete protection to the fraction of people who respond to vaccines



There may be a correlate of protection

Types of vaccine effect measures

Direct effect

- The biological protection of the vaccine
- Relative risk of vaccinated individual compared to unvaccinated

Indirect effect

- The degree of protection that unvaccinated individuals receive in the presence versus the absence of a vaccine program,
- at a given level of coverage

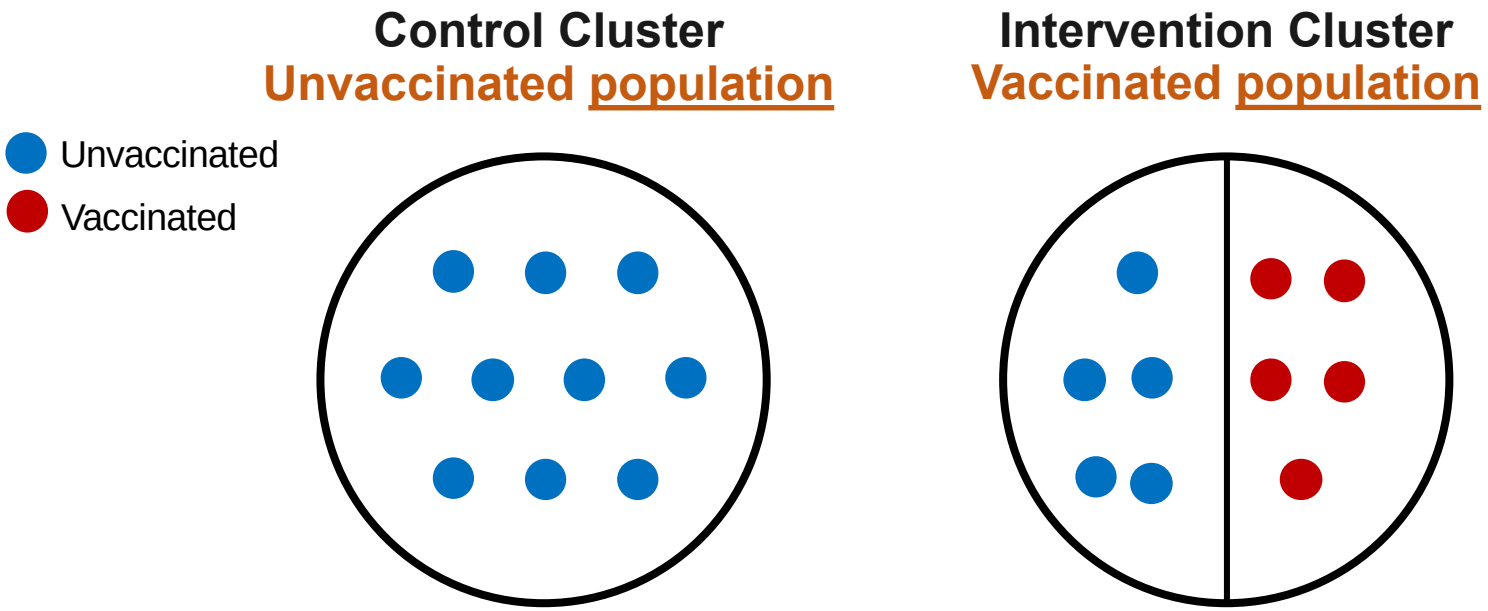
Total effect

- Relative risk of vaccinated individuals in vaccinated population to unvaccinated individuals in unvaccinated population,
- at a given level of coverage

Overall effect

- Relative risk of average individual in a population with a vaccination program to an average individual in a comparable population with no vaccination,
- at a given level of coverage

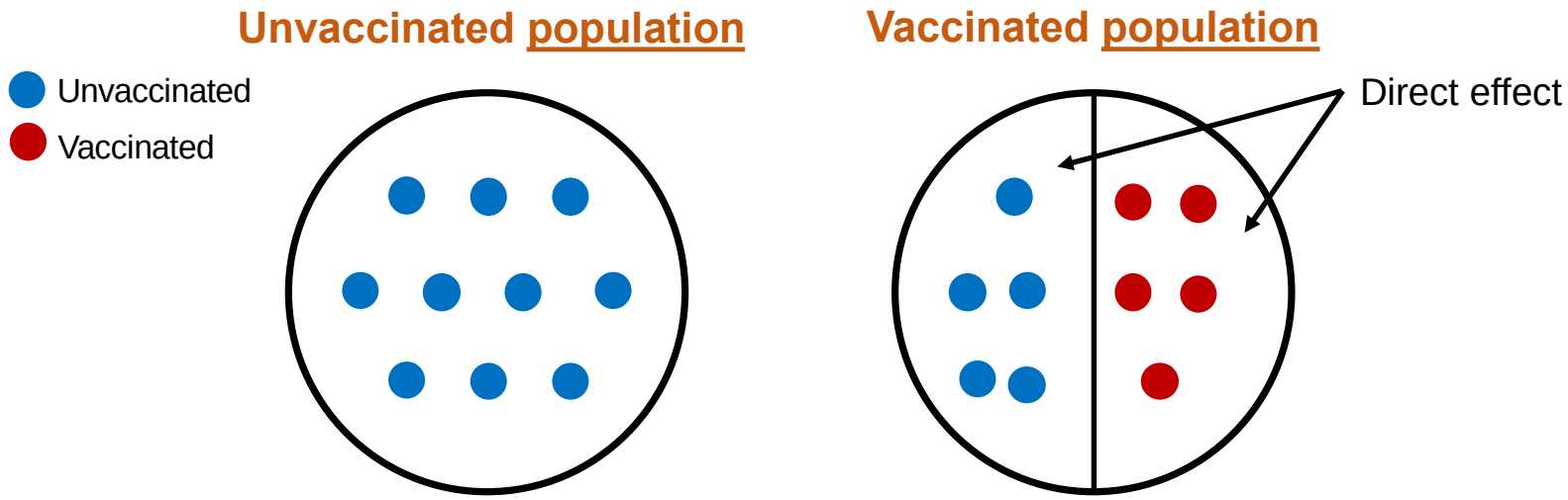
Evaluation of Vaccine Effects



Based on Halloran et al, *Am J Epidemiol* (1997)

Direct effectiveness

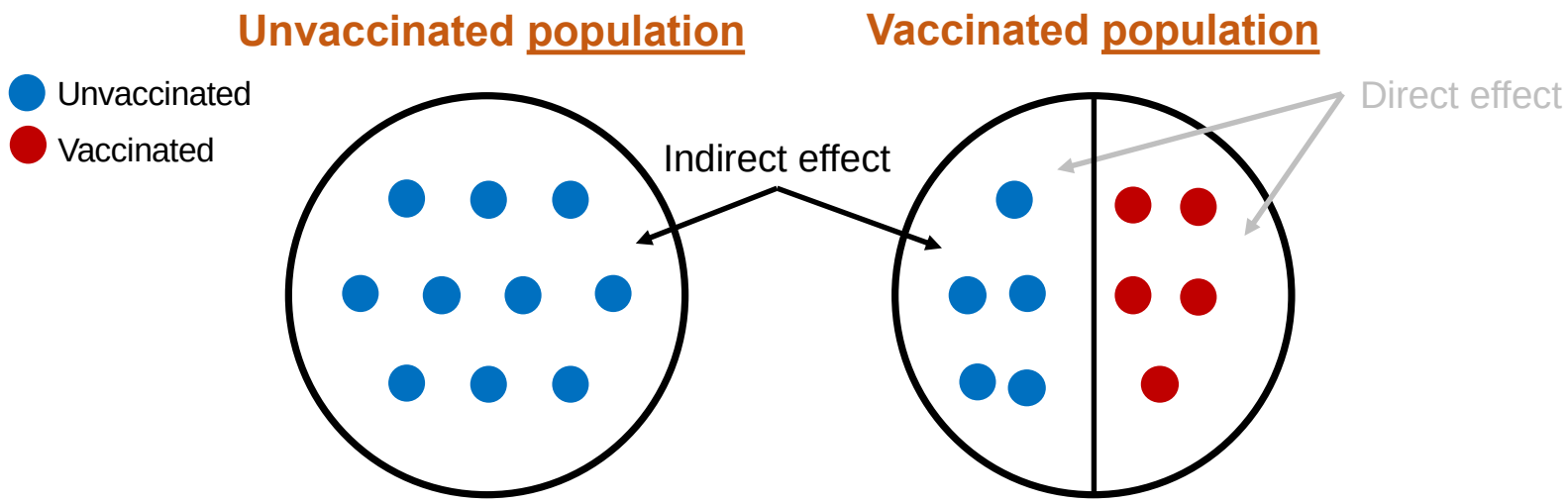
- Biological protection of a vaccine



Based on Halloran et al, *Am J Epidemiol* (1997)

Indirect effectiveness

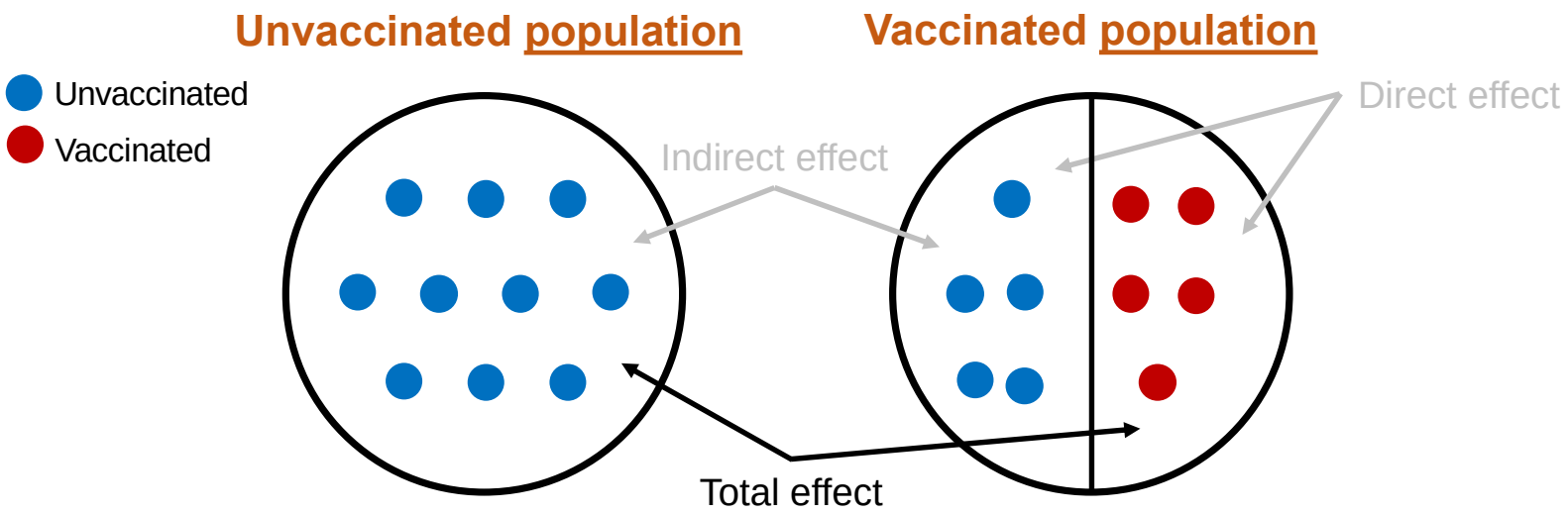
- "Herd protection"
- Protection that unvaccinated individuals receive in the presences versus absence of a vaccination program



Based on Halloran et al, *Am J Epidemiol* (1997)

Total effectiveness

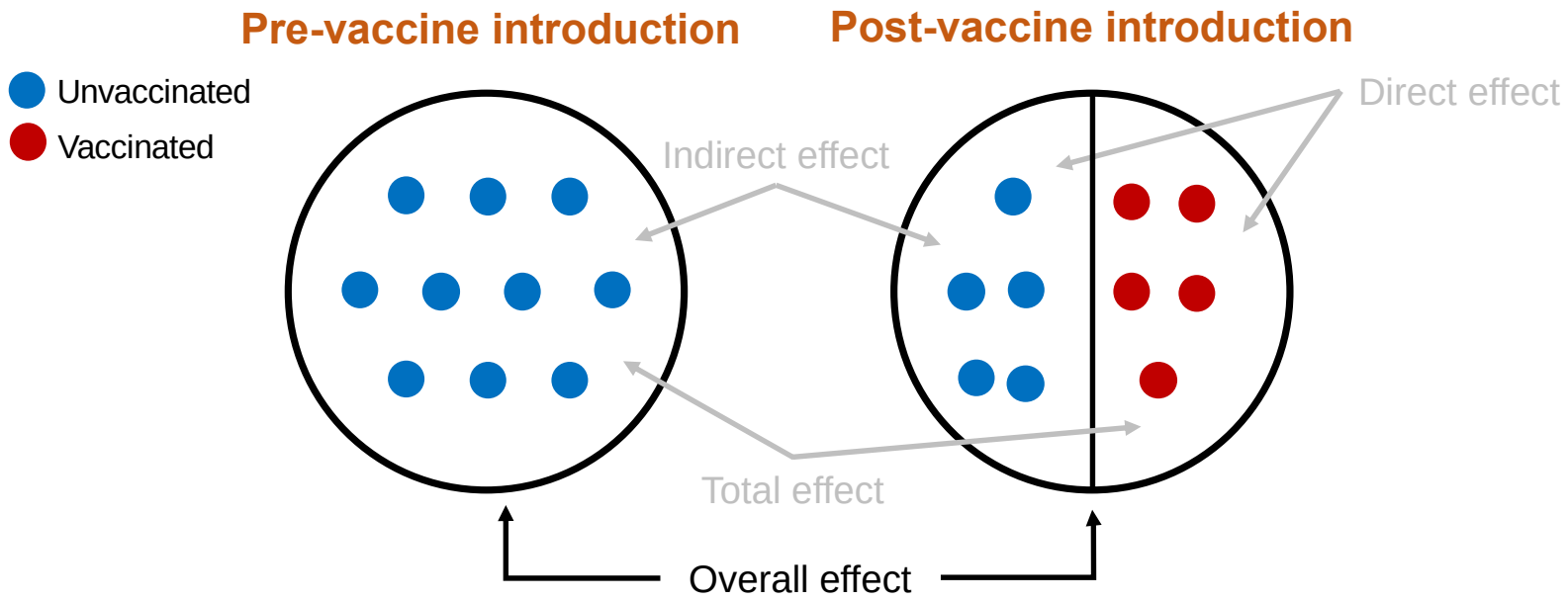
- The combination of biologic and indirect protection received by vaccinated individuals



Based on Halloran et al, *Am J Epidemiol* (1997)

Overall effectiveness

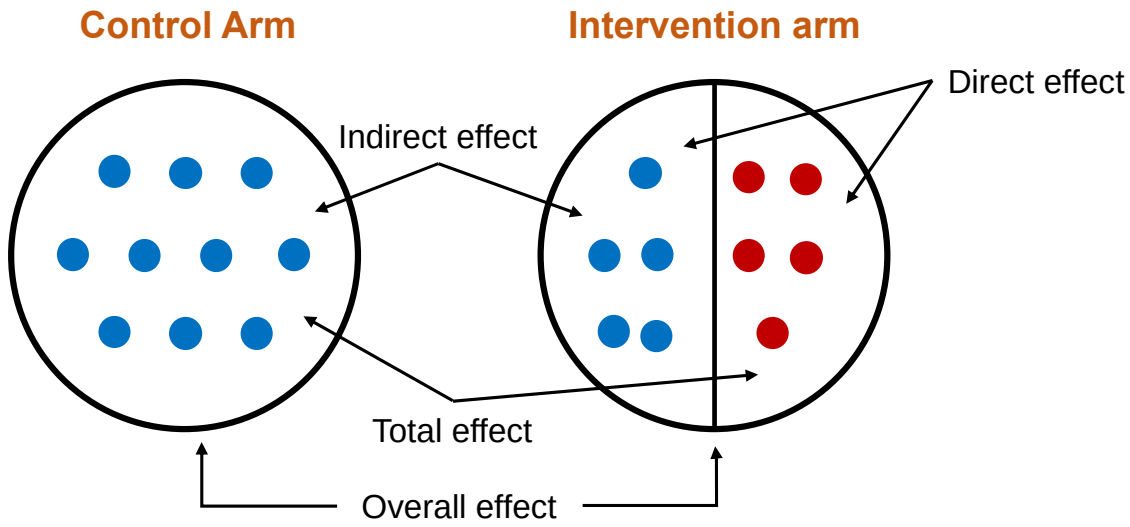
- "Vaccine impact"
- Public health benefit of a vaccination program, weighting total effects among vaccinated and indirect effects among unvaccinated populations



Based on Halloran et al, *Am J Epidemiol* (1997)

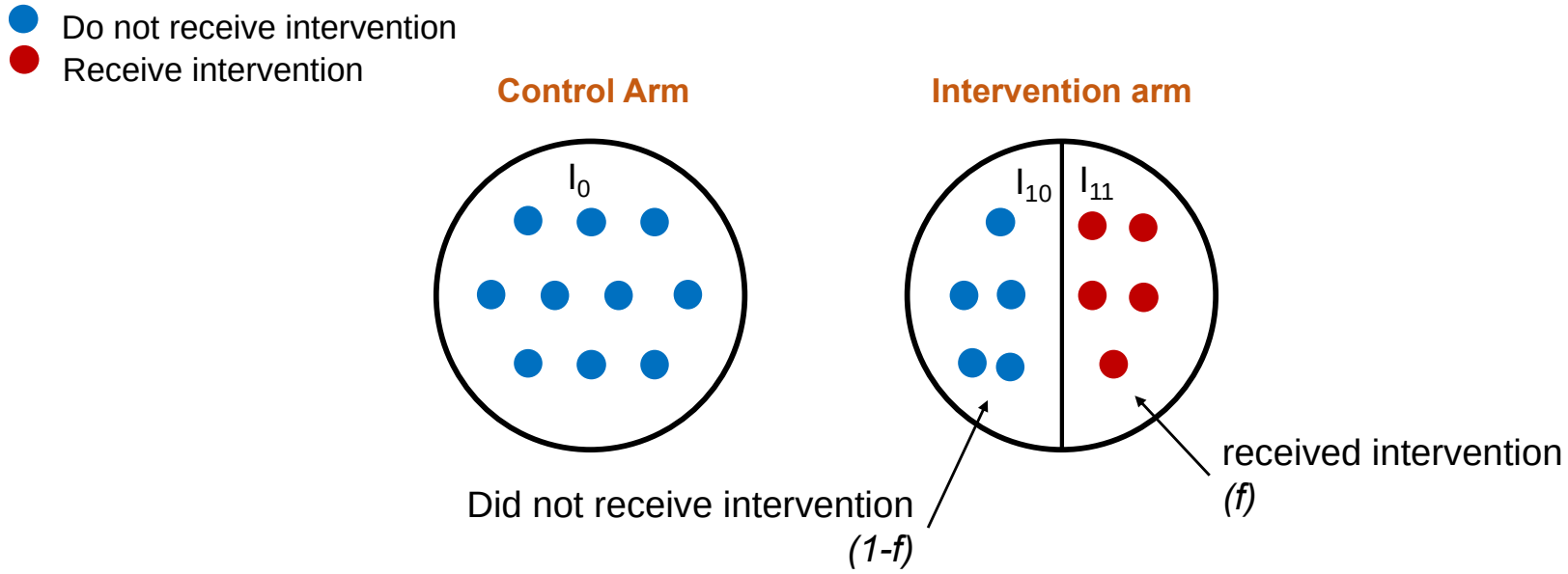
Intervention effects

Do not receive intervention
Receive intervention



Based on Halloran et al, *Am J Epidemiol* (1997)

Intervention effects -- Notation



Based on Halloran et al, *Am J Epidemiol* (1997)

Calculation of effects

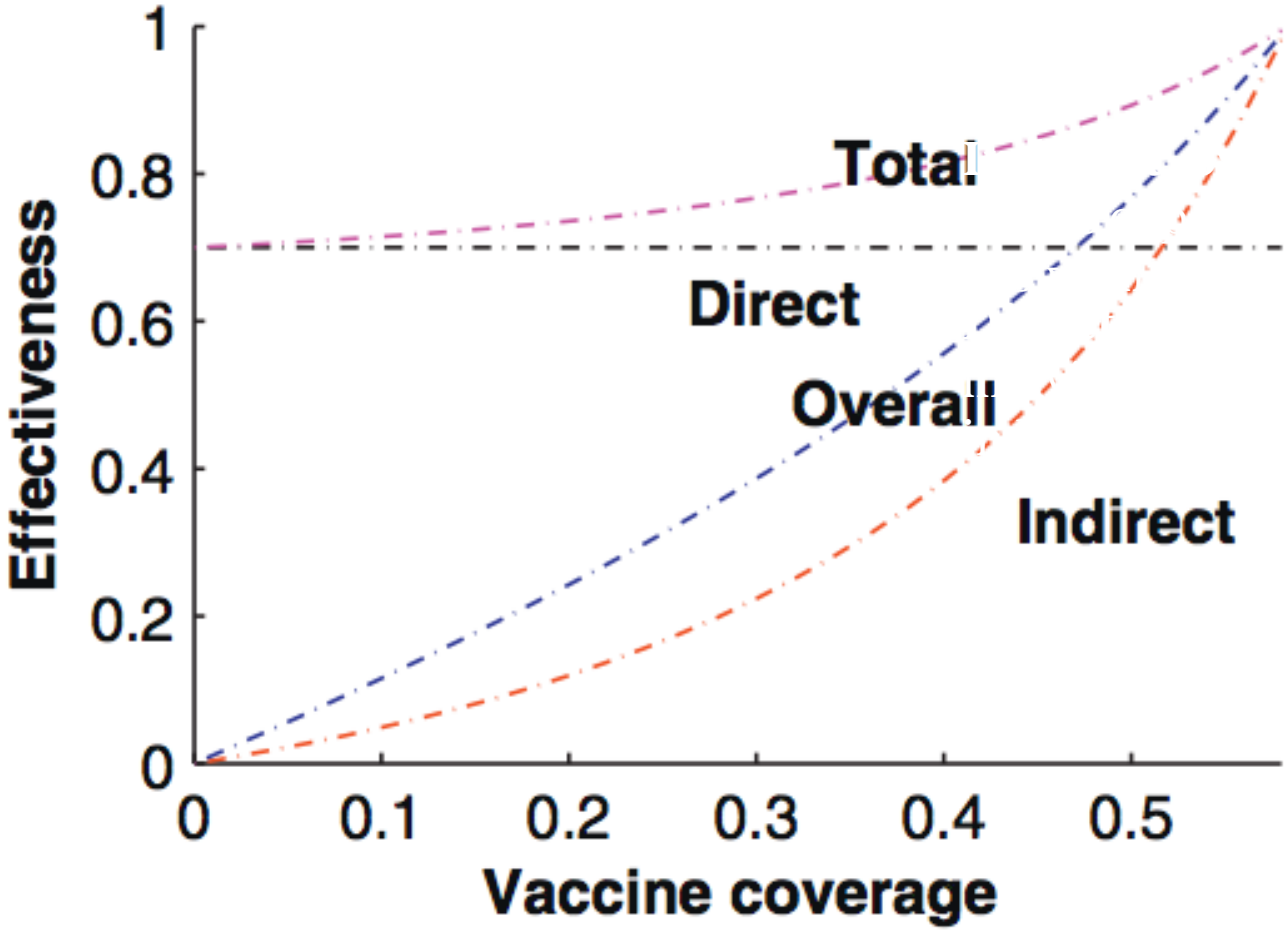
$$VE_{direct} = \left(1 - \frac{I_{11}}{I_{10}}\right) * 100\%$$

$$VE_{indirect} = (1 - \frac{I_{10}}{I_0}) * 100\%$$

$$VE_{overall} = (1 - \frac{I_1}{I_0}) * 100\%$$

$$VE_{total} = (1 - \frac{I_{11}}{I_0}) * 100\%$$

Which vaccine effects depend on coverage?



RESEARCH ARTICLE Open Access

Effects of the rotavirus vaccine program across age groups in the United States: analysis of national claims data, 2001–2016

Julia M. Baker[1,2*], Rebecca M. Dahl[3], Justin Cubilo[1], Umesh D. Parashar[2] and Benjamin A. Lopman[1,2]

Table 1 Vaccine effectiveness against RVGE hospitalization during the post-vaccine period by age group

Age Group	Direct VE, % (95% CI)	Indirect VE, % (95% CI)	Overall VE, % (95% CI)	Total VE, % (95% CI)
< 1	80* (70, 87)	79* (66, 87)	88* (82, 92)	96* (93, 97)
1	92* (87, 95)	59* (33, 76)	79* (65, 88)	97* (95, 98)
2	87* (76, 93)	43* (4, 67)	68* (44, 83)	93* (86, 96)
3	96* (89, 99)	42 (– 2, 68)	71* (47, 84)	97* (93, 99)
4	81* (53, 93)	36 (– 25, 68)	59* (22, 79)	88* (70, 96)
0–4	87* (83, 90)	60* (48, 69)	78* (71, 83)	95* (93, 96)
5–9	47 (– 12, 79)	48* (30, 61)	50* (34, 63)	72* (42, 89)
10–14		46* (14, 67)	Equivalent to indirect VE[a]	
15–24		42* (10, 62)		
25–44		56* (36, 70)		
45–64		35* (9, 53)		
All ages			69* (62, 76)	

*Represents significance at the alpha = 0.05 level

[a]Indirect and overall VE are equivalent for children, adolescents, and adults over 9 years of age because there are no vaccinated individuals in these age groups

https://bmcinfectdis.biomedcentral.com/articles/10.1186/s12879-019-3816-7

Summary

Vaccines may act against infection, disease or infectiousness

Two concepts of vaccine action

- All-or-nothing
- Leaky

Types of vaccine effects – the latter 3 depend on coverage

- Direct
- Indirect
- Total
- Overall