Measuring national HIV incidence
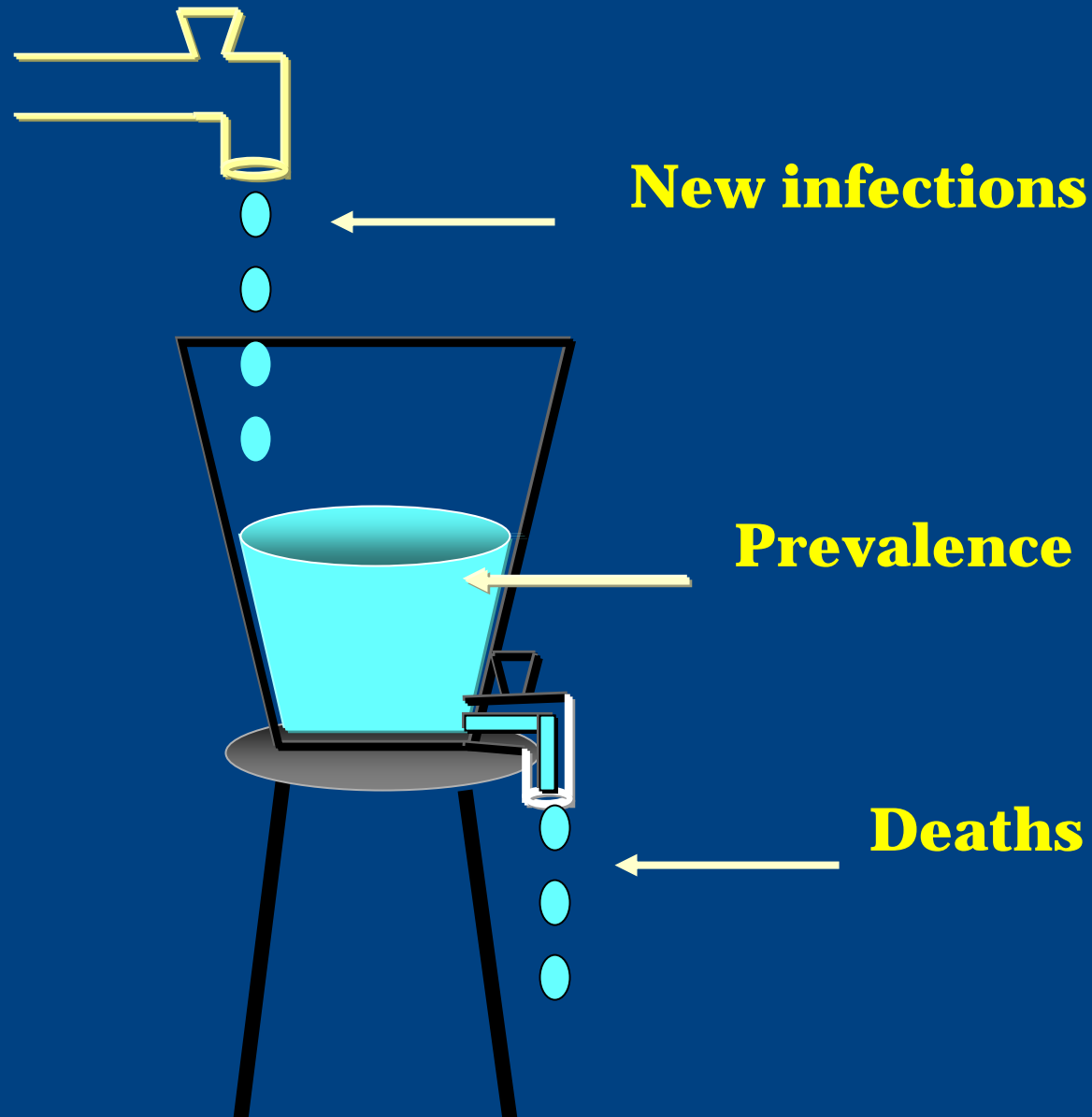
Metropolitan,
December 7, 2007

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Prevalence = incidence X average duration
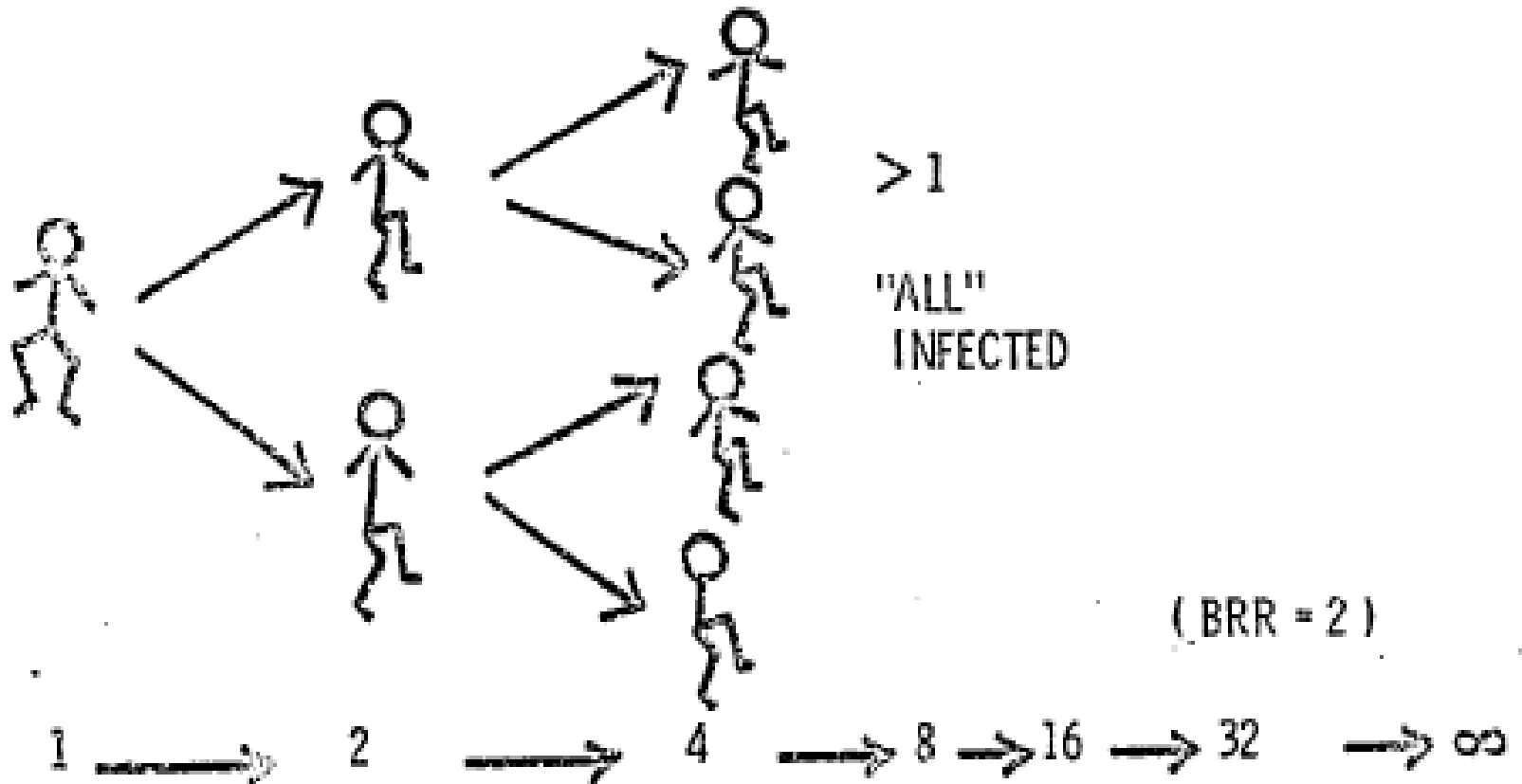
Basic reproductive rate R_o

$R_0 = \beta c D$

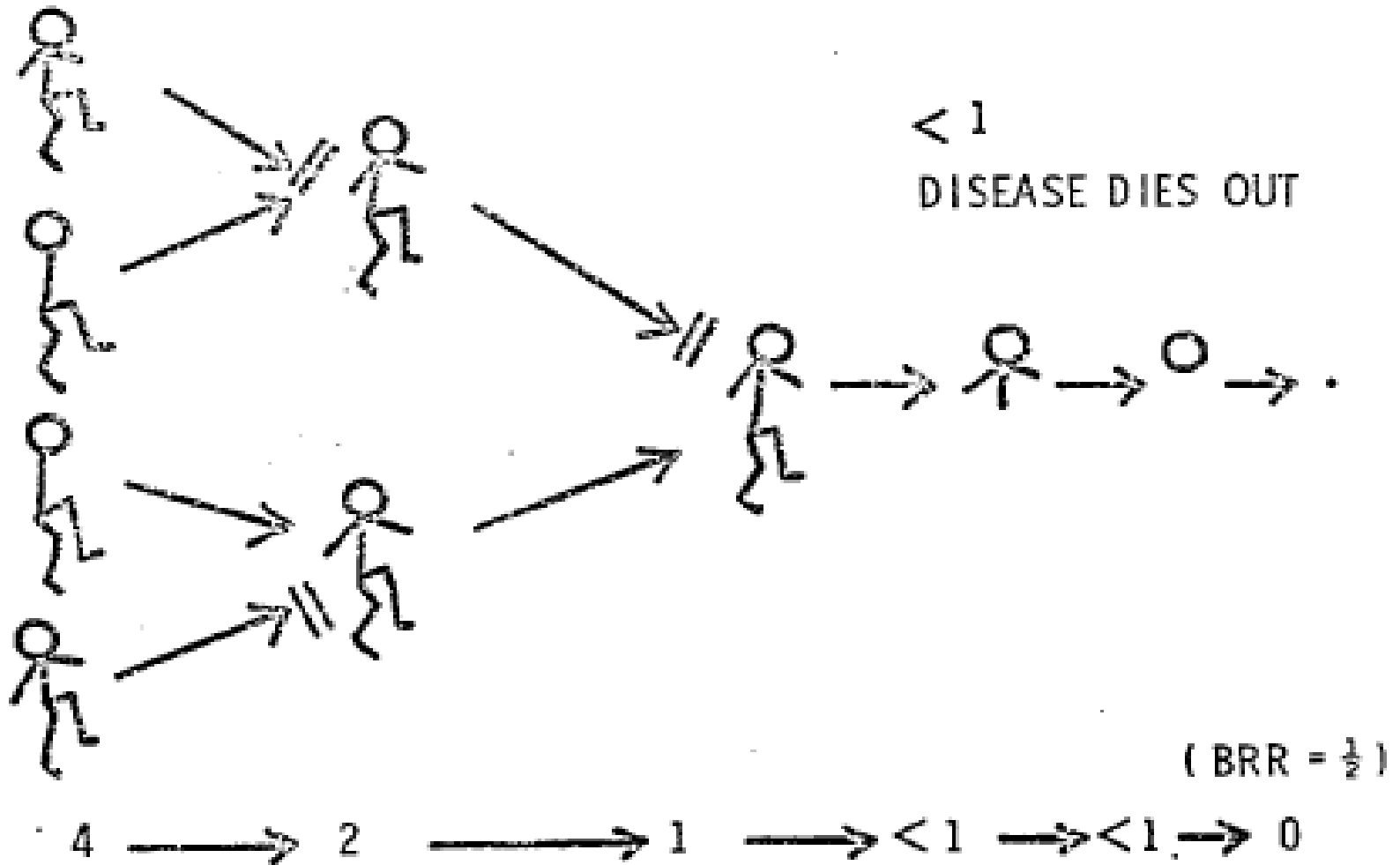β = Average probability of HIV transmission per exposure to an infectious partner

c = Number of exposures of susceptible persons to infectious partners per unit time

D = Duration of infectious period

Basic Reproductive Rate

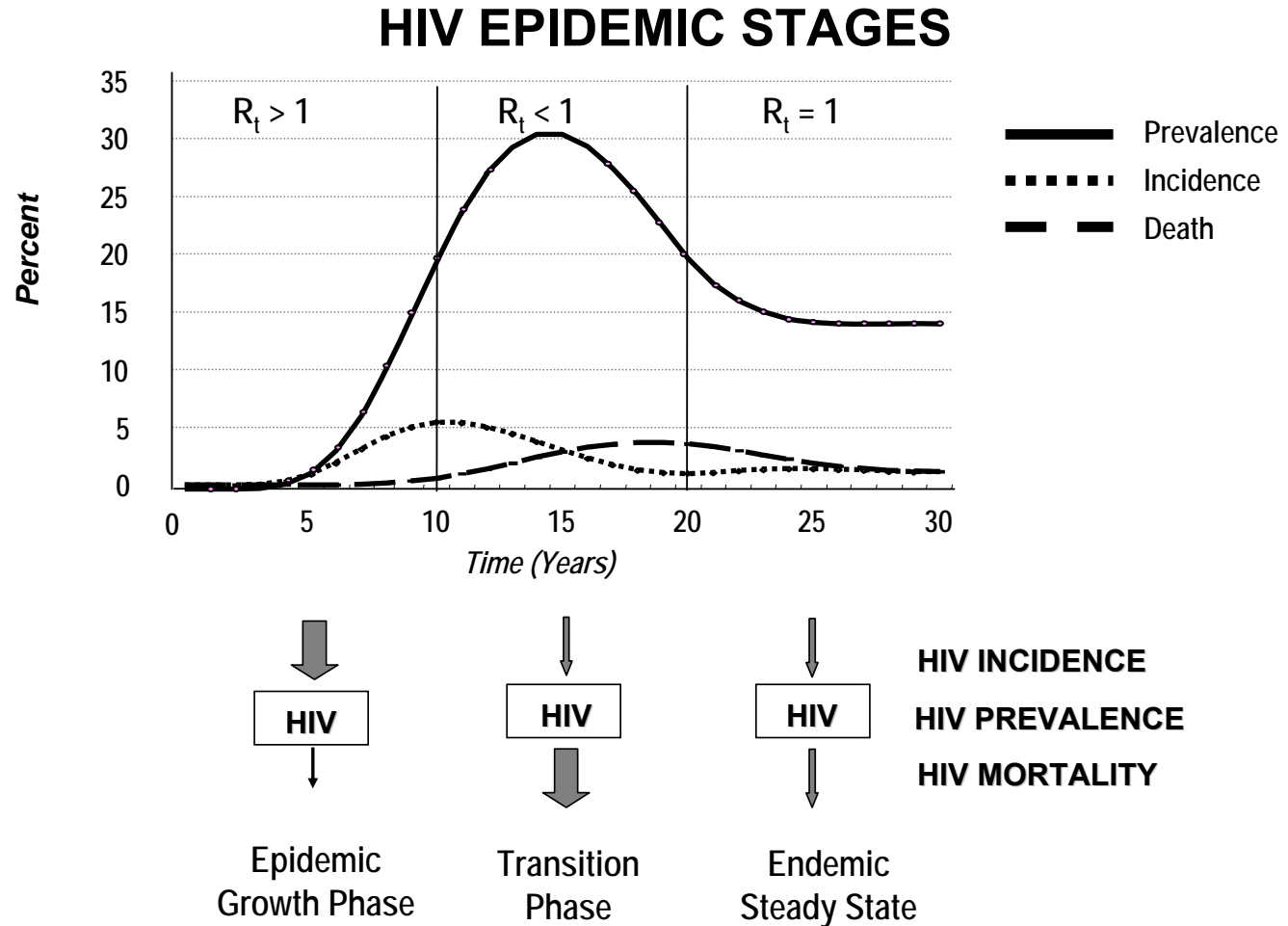> 1

"ALL" INFECTED

(BRR = 2)

1 ⟶ 2 ⟶ 4 ⟶ 8 ⟶ 16 ⟶ 32 ⟶ ∞

Basic Reproductive Rate

< 1
DISEASE DIES OUT

(BRR = $\frac{1}{2}$)

4 ⟶ 2 ⟶ 1 ⟶ <1 ⟶ <1 ⟶ 0

Relationship between incidence, prevalence, and mortality

HIV EPIDEMIC STAGES

Critical Questions

Are the observed changes in the prevalence of HIV:

1. a reflection of the natural history of the epidemic?

2. a product of changes in behavior?
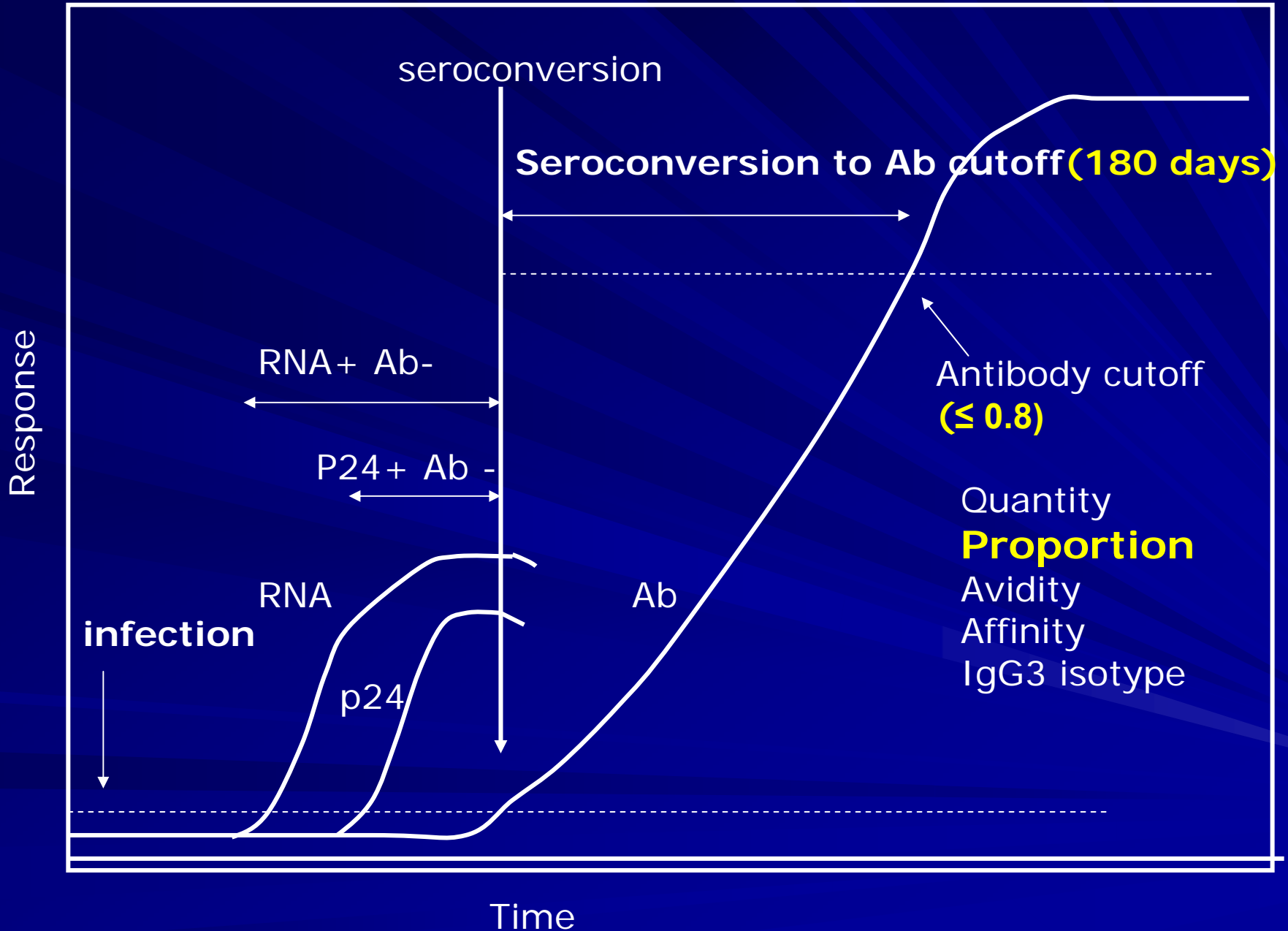
3. a product of interventions?

Factors Contributing to Observed Changes in HIV Prevalence

- **Mortality, especially in mature epidemics**

- **Saturation effects in populations at high infection risk**

- **Decrease in new HIV infections as a result of behavior change:**

  - **Effect of interventions**

  - **Spontaneous (e.g. close friend with HIV/AIDS)**

- **Decrease in the prevalence of biological cofactors e.g. STIs**

- **Decrease in deaths in HIV infected persons as a result of antiretroviral therapy (ART)**

- **Population differentials related to in- and out migration patterns**

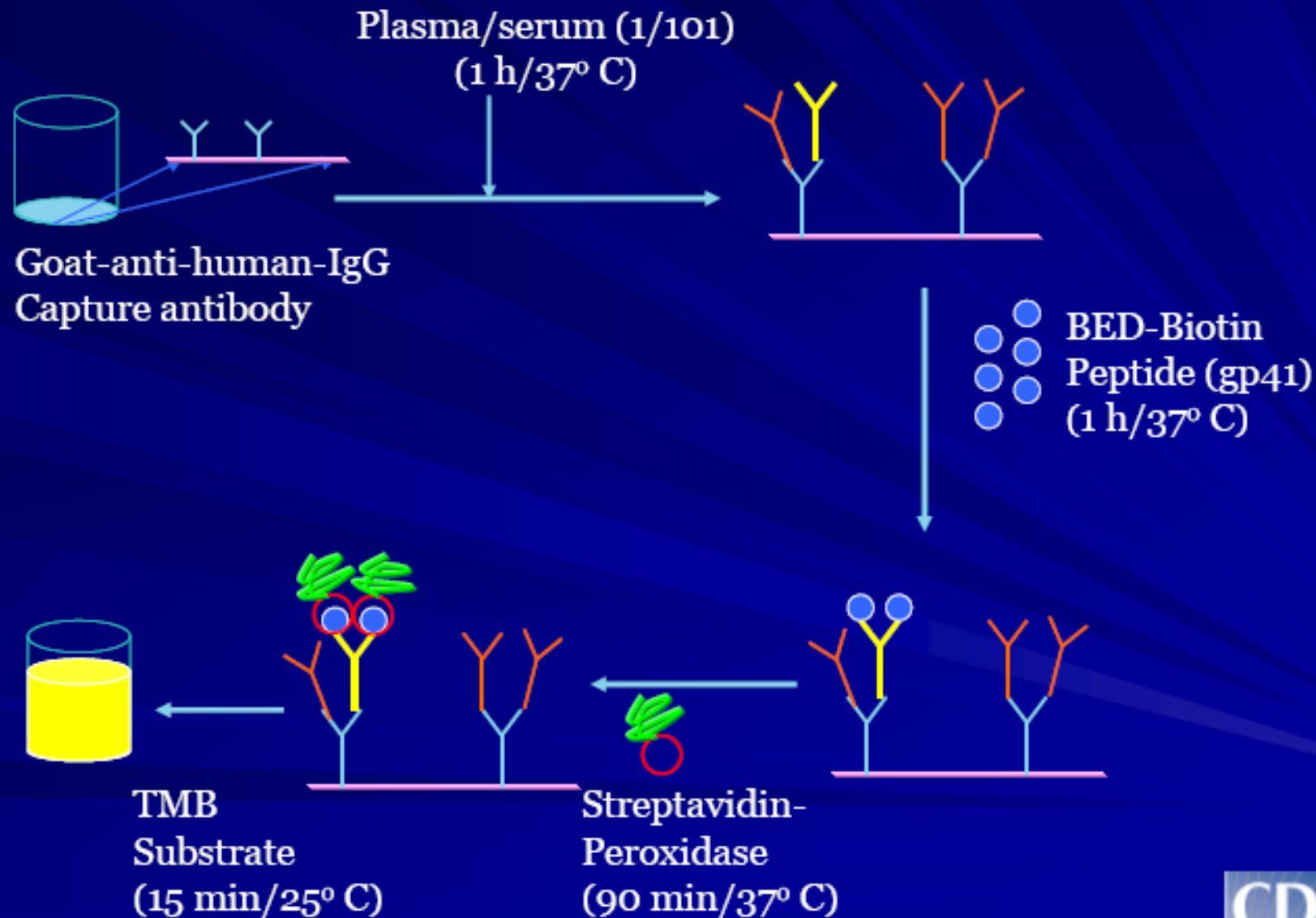- **Sampling bias and/or errors in data collection**

Estimating HIV incidence

- **Epidemiological methods**

  - **Cohort studies** *(directly observed incidence)*

  - **HIV prevalence in youngest age group (15-20)**

   (as a proxy for recent infection)

  - **Mathematical modeling** *(indirect incidence estimate)*

- **Laboratory- based methods**

  (direct incidence measure from cross-sectional surveys)

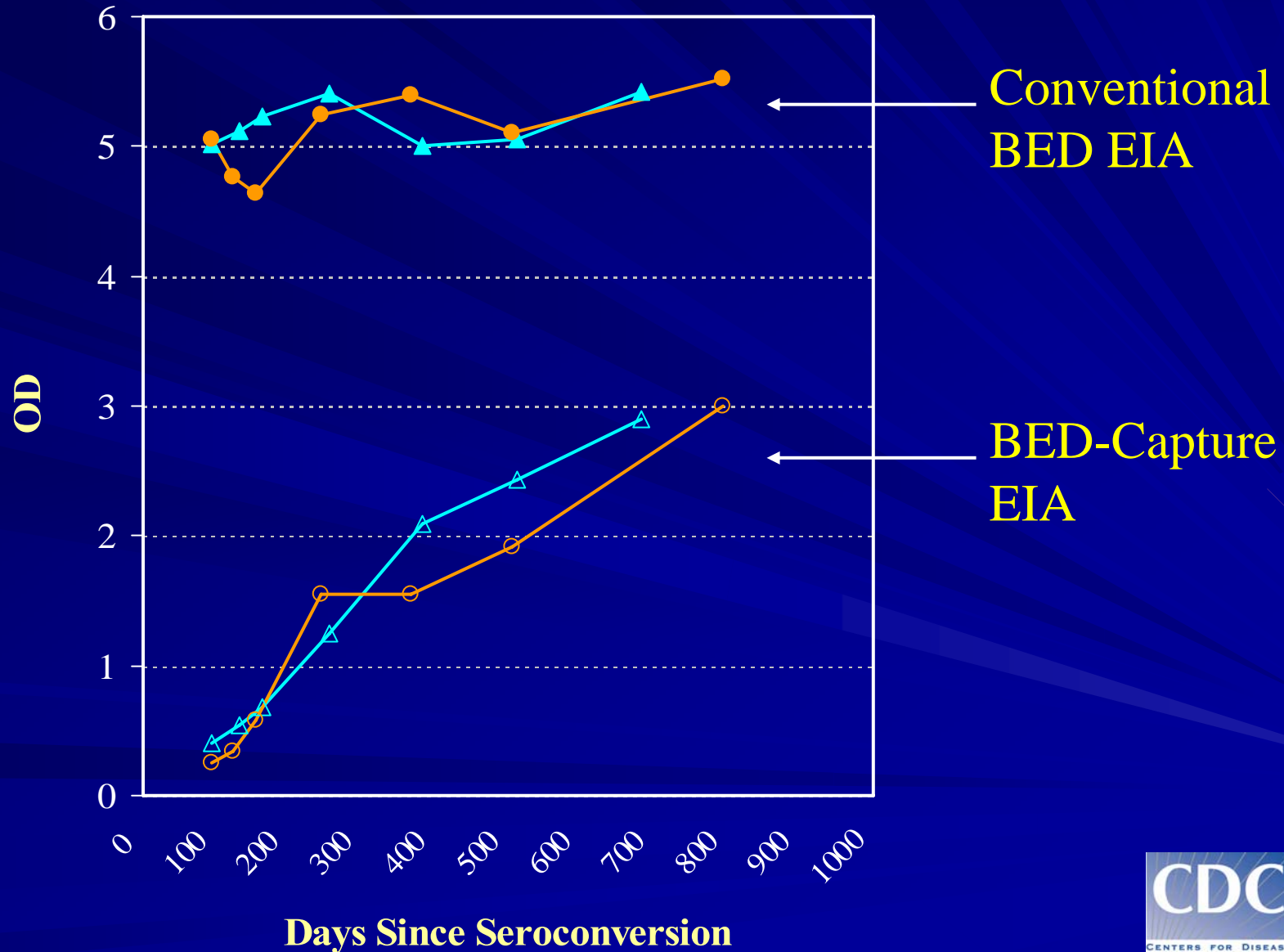# Schematic of the BED-CEIA

Plasma/serum (1/101)
(1 h/37° C)

Goat-anti-human-IgG
Capture antibody

BED-Biotin
Peptide (gp41)
(1 h/37° C)

TMB
Substrate
(15 min/25° C)

Streptavidin-
Peroxidase
(90 min/37° C)

CDC
Centers for Disease
Control and Prevention

Comparison of Conventional EIA (antigen coated plates) and BED-Capture EIA

BED window periods at 0.8 cutoff

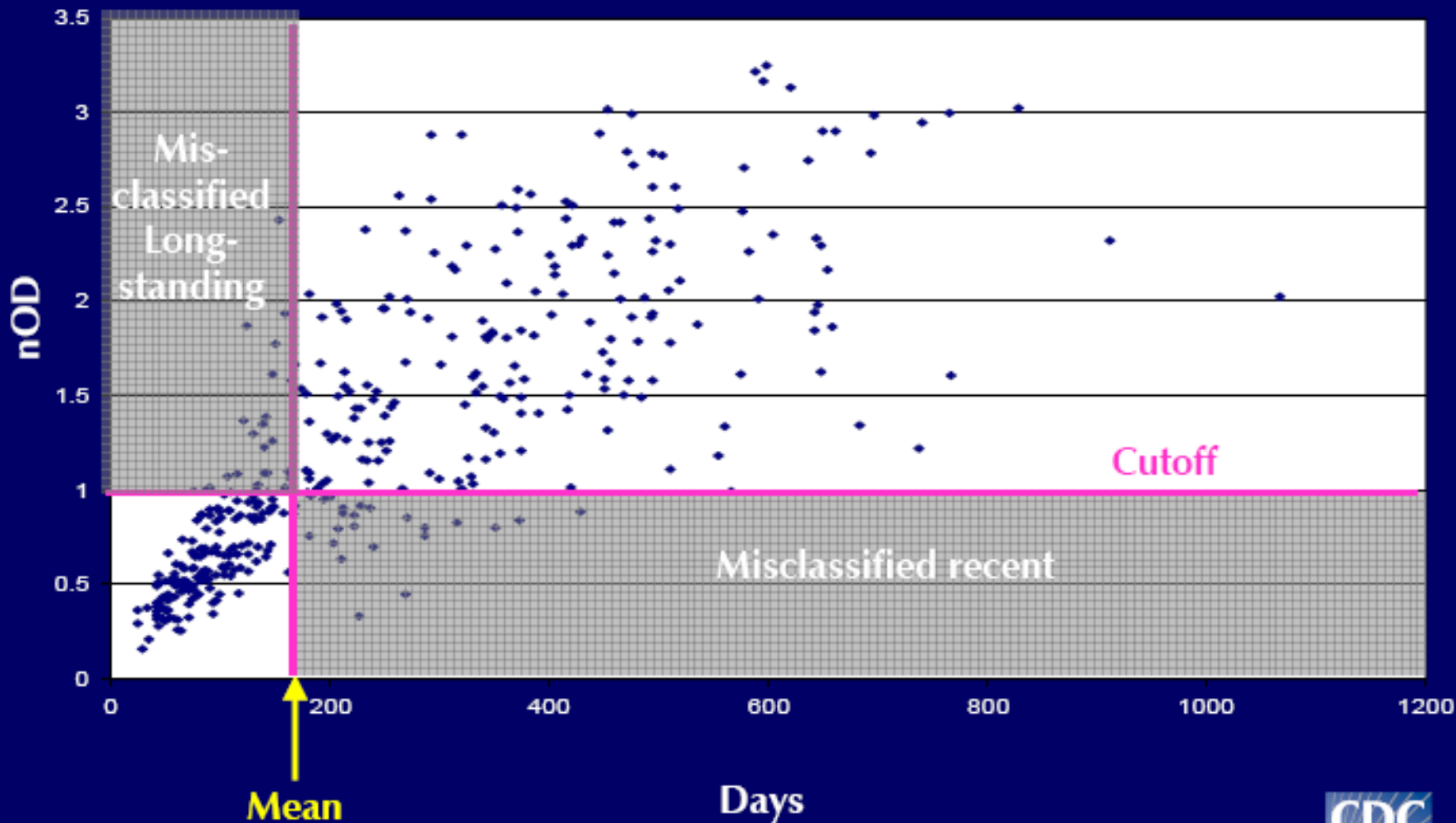| Subtypes	Country	Window (95% CI)
AD	Kenya	171 (150-199)
B	Amsterdam	127 (113-152)
B	Thailand	143 (118-170)
C	**Zimbabwe**	**181 (165-198)**
C	Ethiopia	167 (154-180)
E	Thailand	115 (106-125)
OVERALL		155 (146-165)

Calibration of window period

Zimbabwe Cohort / subtype C
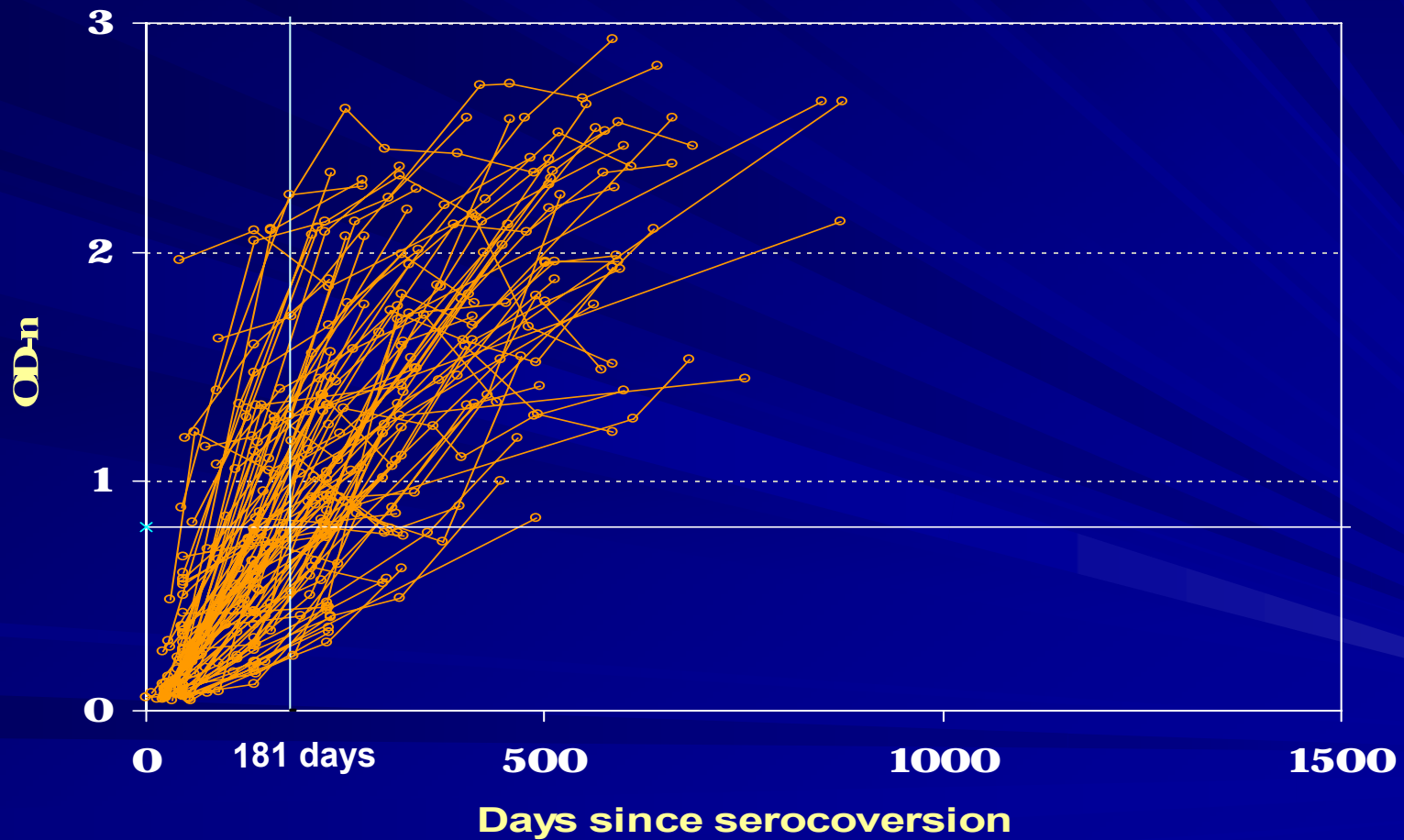
Window Period Estimates: Incidence

BED incidence adjustments

- **UNAIDS 2005: BED overestimates HIV incidence in cross-sectional studies**

- **BED validation meeting, CDC 2006:**
  - **Sensitivity/Specificity Adjustment (McDougal et al.)**
  - **Specificity Adjustment (Hargrove et al.)**
  - **Validated for HIV-1 subtypes B and C**
    (2 532 specimens from 1 192 individuals)

BED HIV incidence calculation

$$I = \frac{F(365/w) N_{inc}}{N_{neg} + F(365/w) N_{inc}/2} \times 100$$

Adjustment Factor
(McDougal)

$$= \frac{(R/P) + \gamma - 1}{(R/P)(\alpha - \beta + 2\gamma - 1)}$$

Window period = 180 days

Incidence = number of new infections per year per 100 persons at risk (% / year)
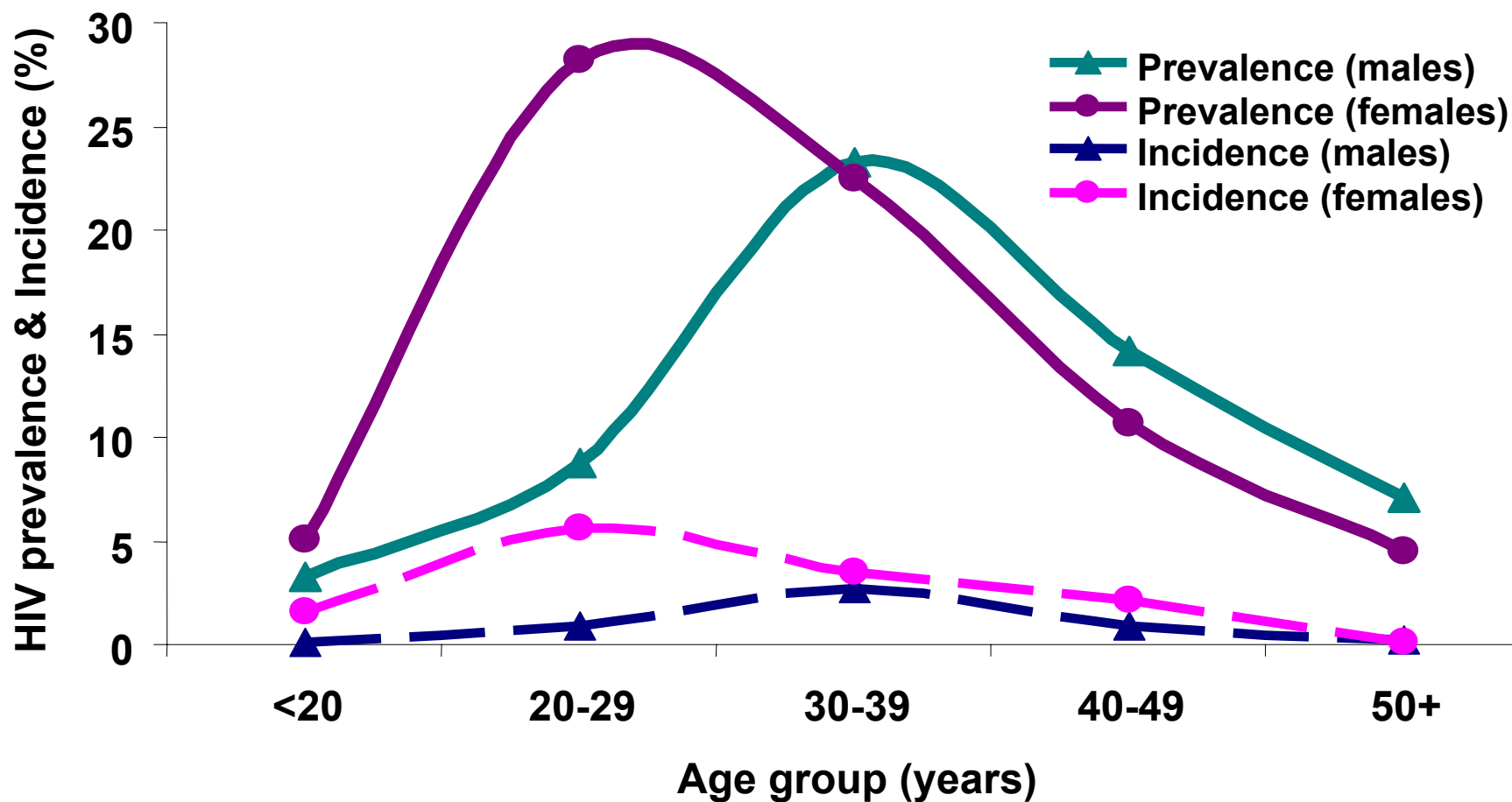
National HIV Household Survey South Africa 2005

- **Study population: 2 years and older**
- **Anonymous HIV testing of dried blood spot specimens**
- **HIV prevalence and HIV incidence**
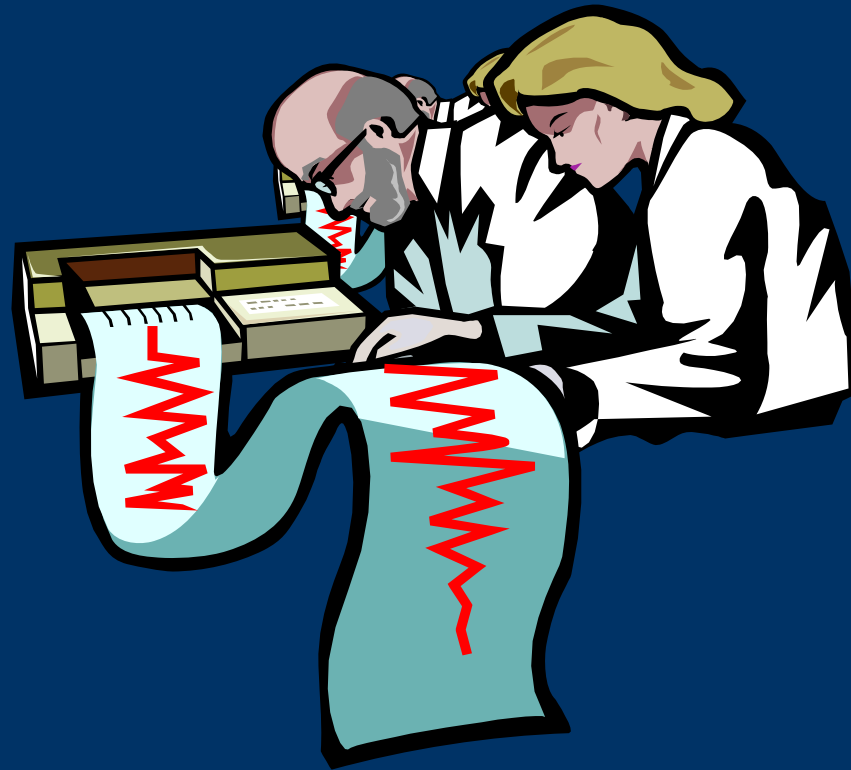- **Final sample: 23 275 interviewed, 15 851 tested for HIV**

HIV incidence % and number of new infections by age group, South Africa 2005

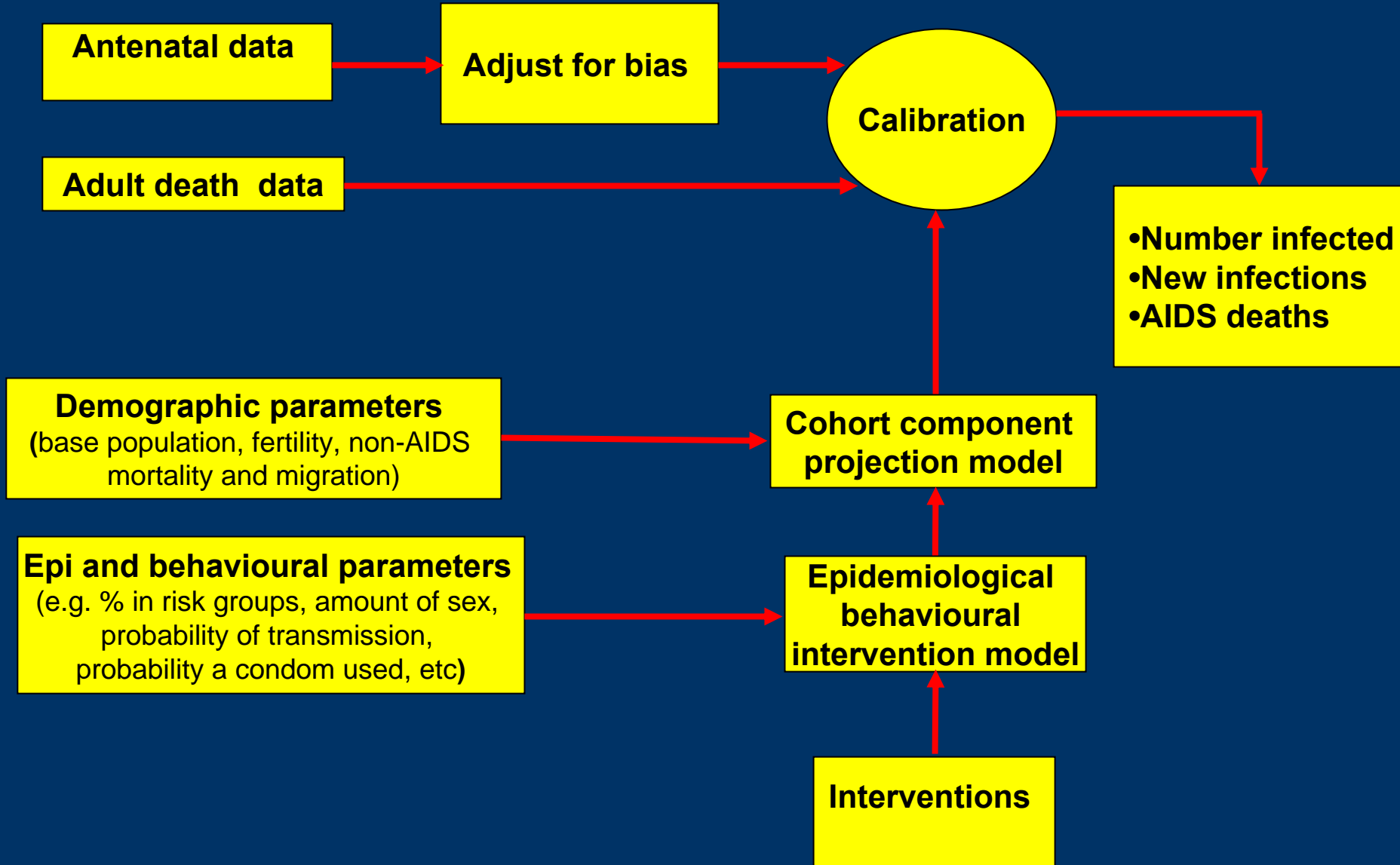| Age group (years)	Weighted sample (n)	HIV incidence % per year [95%CI]	Estimated number of new infections per year (n)
≥ 2	44 513 000	1.4 [1.0 - 1.8]	571 000
2-14	13 253 000	0.5 [0.0 - 1.2]	69 000
15-24	9 616 000	2.2 [1.3 - 3.1]	192 000
15-49	24 572 000	2.4 [1.7 – 3.2]	500 000

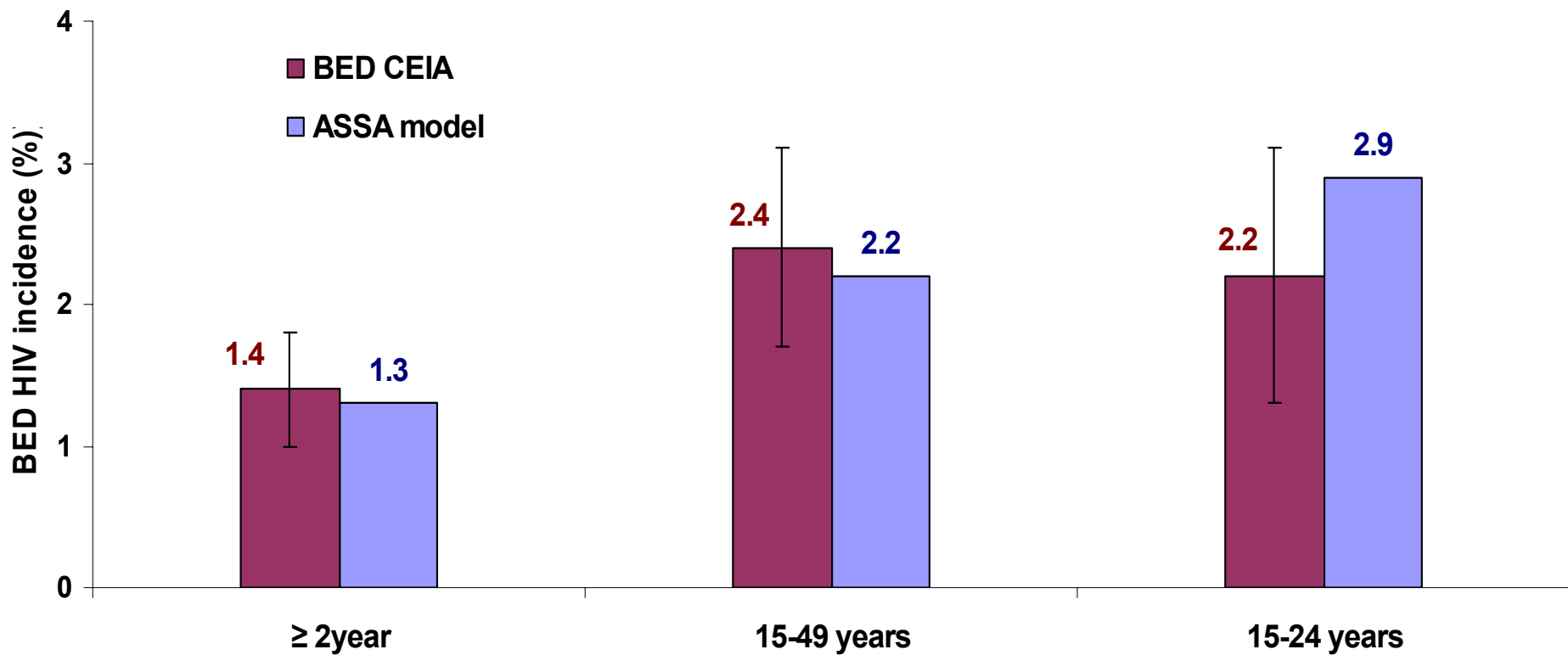# HIV prevalence and HIV incidence by age and sex, South Africa 2005

Are the adjusted BED HIV incidence estimates plausible?

ASSA model

Antenatal data → **Adjust for bias** → **Calibration**

Adult death data → **Calibration**

Calibration →
- Number infected
- New infections
- AIDS deaths

Demographic parameters (base population, fertility, non-AIDS mortality and migration) → **Cohort component projection model**

Epi and behavioural parameters (e.g. % in risk groups, amount of sex, probability of transmission, probability a condom used, etc) → **Epidemiological behavioural intervention model**

Interventions → **Epidemiological behavioural intervention model** → **Cohort component projection model** → **Calibration**
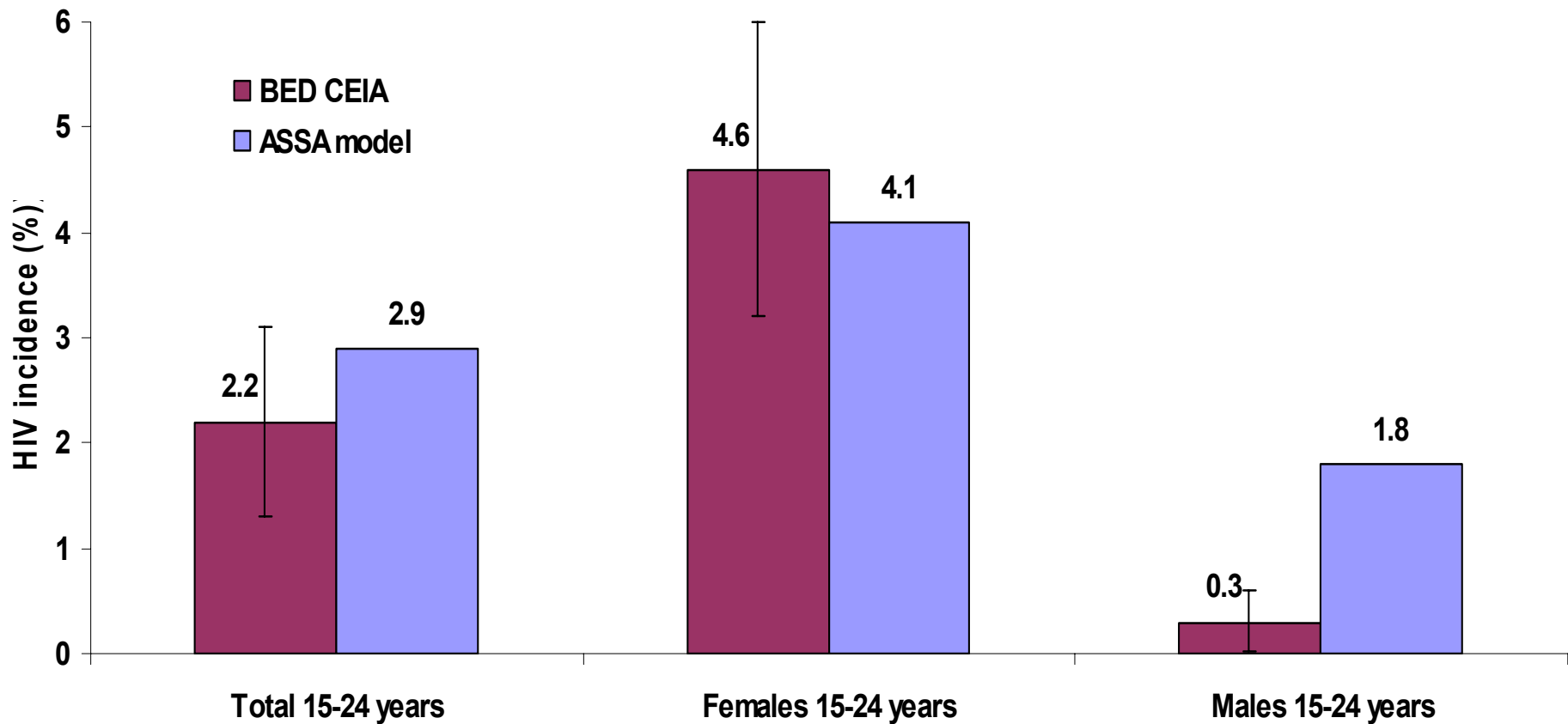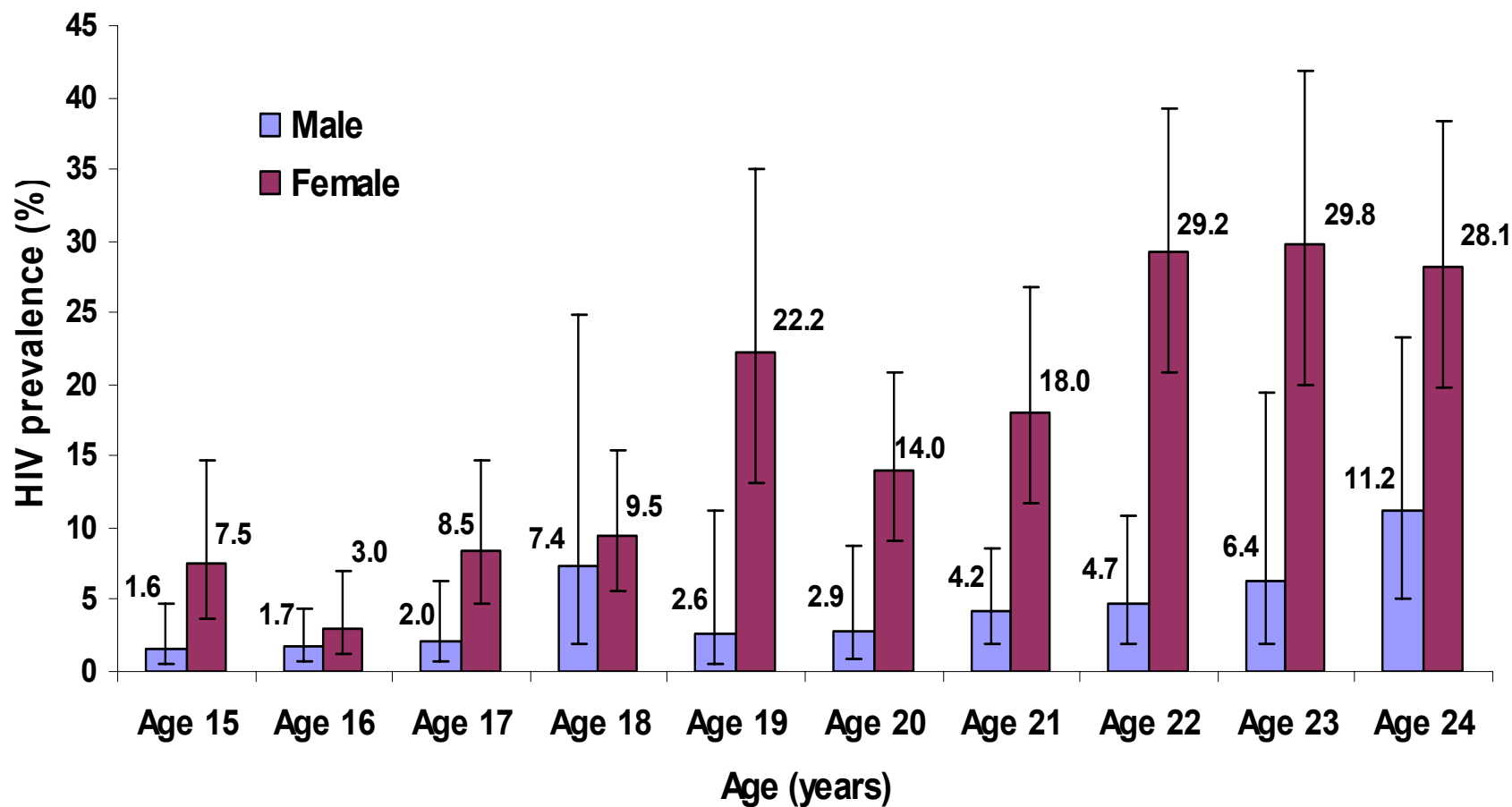
BED HIV incidence vs ASSA model (estimates for 2005)

BED HIV incidence vs ASSA model: male and female youth 15-24 years

HIV prevalence in youth by single year of age HSRC 2005

HIV incidence and behaviour HSRC 2005 (age group 15 – 49 years)

Variable	HIV incidence (% per year)
Marital status	
Single	3.0
Married	1.3
Widowed	5.8
Sexual history	
Sexually active in the past 12 months	2.4
Current pregnancy	5.2
Condom use at last sex (15-24 yrs)	
Yes	2.9
No	6.1

Conclusion

- **Incidence estimates enable a more timely analysis of the current HIV-transmission dynamics**

- **The adjusted BED HIV incidence estimates provide valid national HIV incidence estimates for South Africa**

- **Prevention campaigns did not have the desired impact, particularly among young women**

Laboratory-based adjustment: Sequential testing algorithm