IRELAND

Sampling in IEA Studies

2011 IEA General Assembly

Dublin

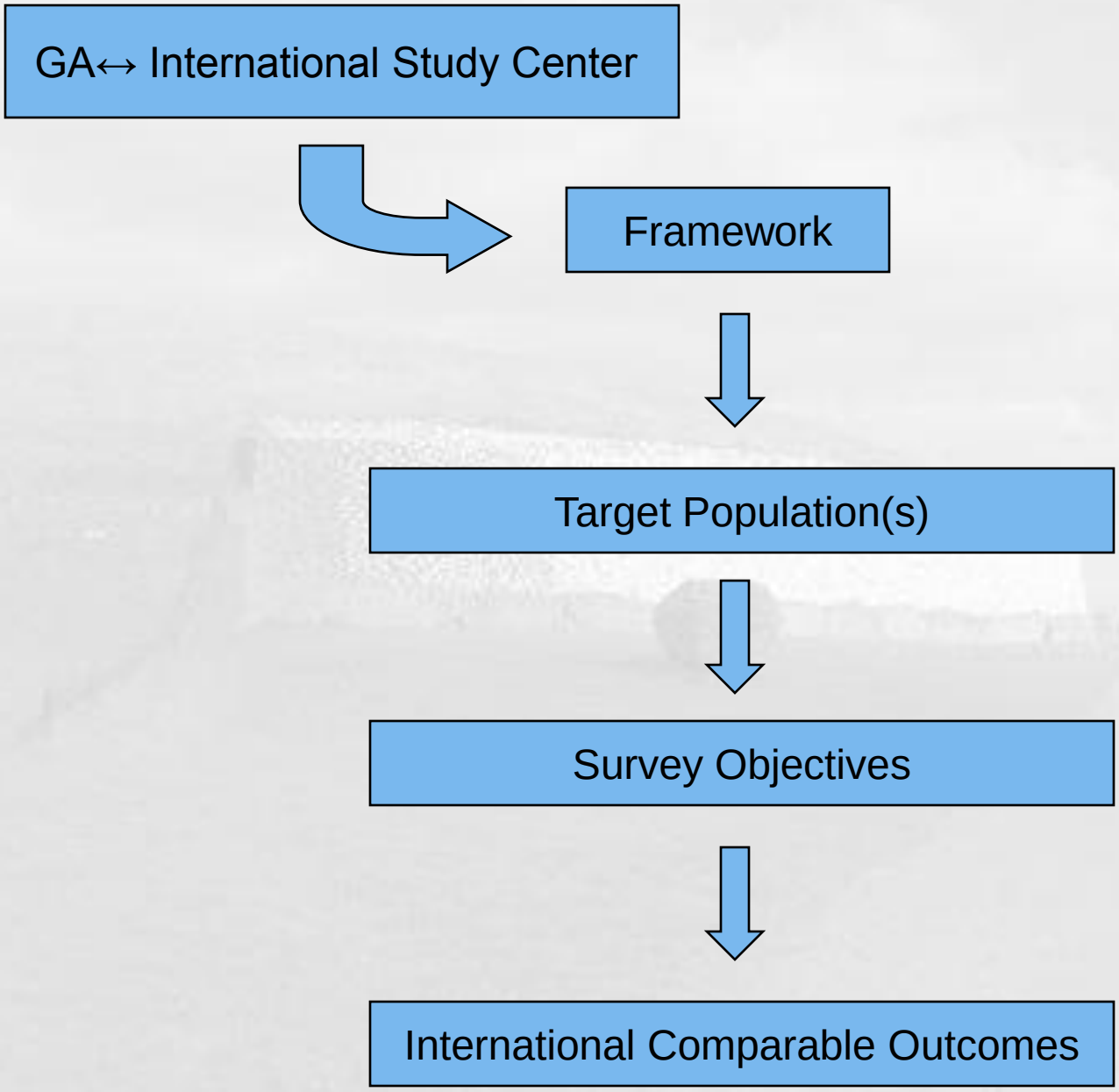
October 12

Introduction

Sampling Challenges

- Target Populations
    - Linking target & survey populations
- Sample Plan Elements
- Sample Plan Implementation
    - Quality standards

Where does sampling fit in the whole study process?


GA↔ International Study Center
Framework
Target Population(s)
Survey Objectives
International Comparable Outcomes

Target Population

- In practice, this is the population for which we want characteristic estimates. It is the population for which information is required
- IEA target population has to be demonstrably comparable among all participating “countries” over time
  - Usually students or teachers within participant “countries“

Survey Objectives

- IEA Multi-purpose survey
  - School, student, teacher statistics
- Areas to be covered
  - National, domain statistics
- Kinds of results expected
  - Ratios, totals, proportions
- Users and uses of the data
  - Researchers, government policy analysts
- Levels of accuracy

International Comparable Outcomes

- Sampling should not be an issue in that regard
  - High quality sample (IEA high standards)
    - Coverage & exclusions
    - Response rates
    - Respect of the sample plan (Complete documentation)

Solution

- Ideal scenario: census of all units belonging to the target population
  - Possible for small participating “countries”
- Practical scenario: sample from the above units
  - The only possibility for most participating “countries”

Solution

- Sampling is acceptable in a IEA context

  if and only if

  - National sampling plans are based on sound and defensible sampling methods
    - Each unit belonging to the target population MUST have a chance to be in the sample (exclusion otherwise)
    - This chance MUST be known (quantifiable) for each unit in the sample
    - Survey results close to census values

Solution

- Sampling is acceptable in a IEA context

  if and only if

  - National sampling plans are based on sound and defensible sampling methods
  - National sampling plans are thoroughly documented
  - National sampling plans are approved by the ISC prior to implementation
  - Sampling standards are met (implementation)

Elements of a Sample Plan

- Sample design
- Estimation procedures
- Procedures to estimate variances

Sampling Design

Sets of specifications describing:

- Target and survey populations;
- Sampling frame;
- Survey units;
- Sample selection method;
- Size of the sample.

Sampling Design

Survey Population

> "The population is the aggregate (or collection) of units to which the survey results apply"

How does this connect to the framework definition known as the "International desired target population"?

IEA Population structure

100% Coverage

≤5%

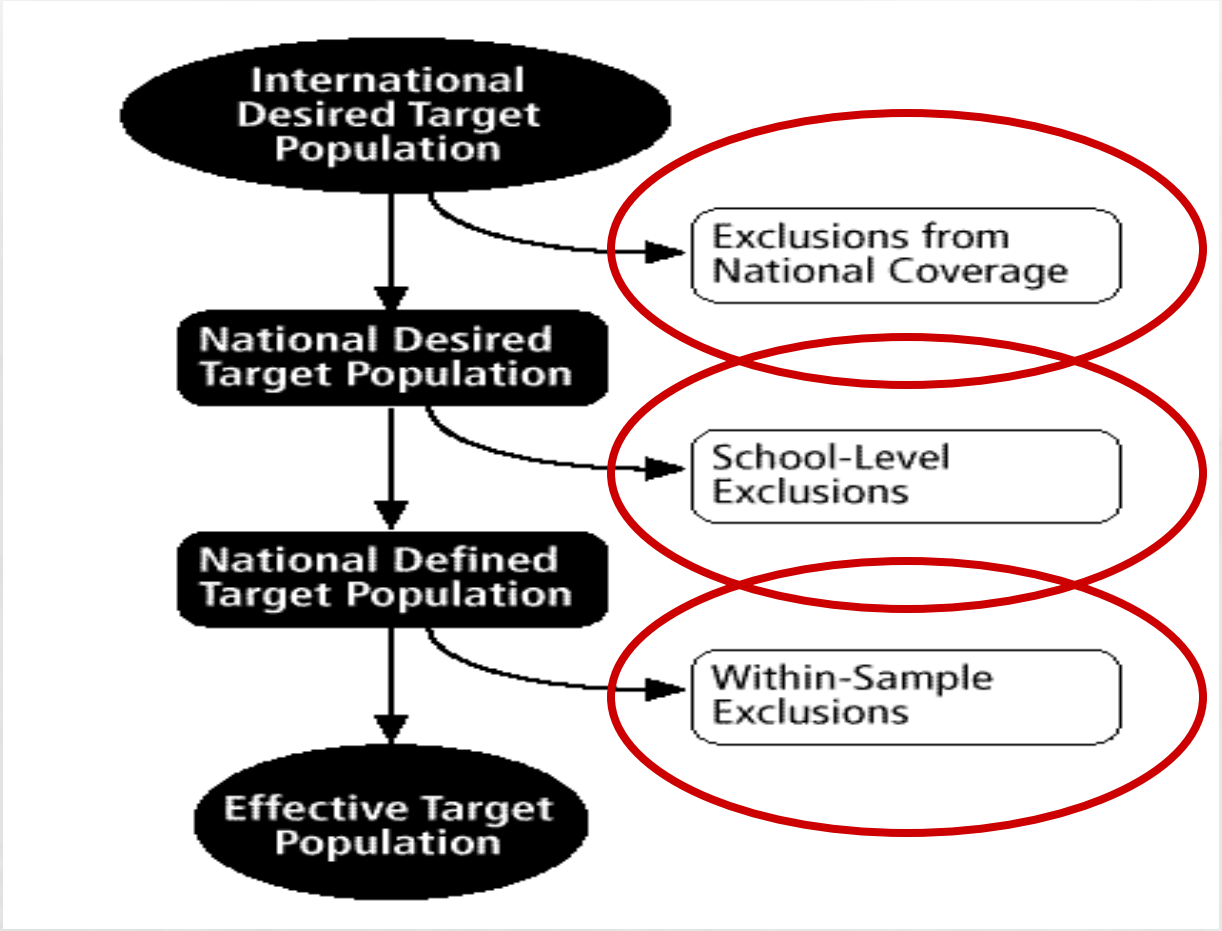
Sampling Frame

- List of units encompassing all individuals and allowing access
- IEA studies: List of schools
  - Lists of students usually not available
  - Takes advantage of the natural population hierarchy (students within classrooms within schools)
  - Reduces collection costs compared to SRS

Sampling Frame

- Sampling frame should have:
  - No incorrect entries, no duplicate entries, or no entries that refer to elements that are not part of the target population
- Information required on the frame:
  - School ID
  - School measure of size (MOS)
  - School status indicator (exclusion categories)
  - Appropriate entries for all stratification variables (public/private, urban/rural, single sex school, etc.)

IEA Population structure



100% Coverage

≤5%

Example

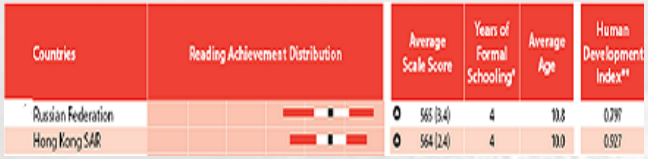
- Difference between the International desired target population and the effective target (survey) population
  - TIMSS & PIRLS 2011 Study

Target Population

2008 / 2009
list of all schools

Prior to
school sampling

International schools
Private schools
Remote schools
Very small schools



2010 / 2011
List of sampled schools

+

New schools
since 2009

Within-School
Exclusions

Special needs
Language

Target Population

2008 / 2009
list of all schools

?

Prior to
school sampling

International schools
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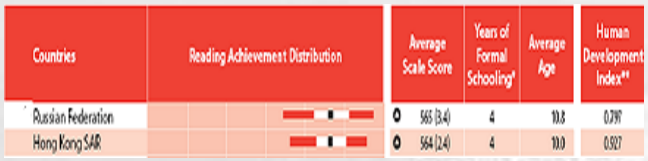


2010 / 2011
List of sampled schools

+

New schools
since 2009

Within-School
Exclusions

Special needs
Language

Under Coverage

A large group accounting for more than 5% of the target population

Exclusions

Small groups each one accounting for less than 5% of the target population

Prior to school sampling

International schools
Private schools
Remote schools
Very small schools

New schools since 2009

Within-School Exclusions

Special needs
Language

- A good list of schools should cover 100% of the target population
- A good sample should be representative of no less than 95% of the international desired target population

Prior to school sampling

International schools
Private schools
Remote schools
Very small schools

New schools since 2009

Within-School Exclusions

Special needs
Language

Target Population

Countries	Reading Achievement Distribution	Average Scale Score	Years of Formal Schooling*	Average Age	Human Development Index**
Italy		551 (2.9)	4	9.7	0.940
Hungary		551 (3.0)	4	10.7	0.869
Sweden		549 (2.3)	4	10.9	0.951
Germany		548 (2.2)	4	10.5	0.932

Users think “all grade 4 students…”

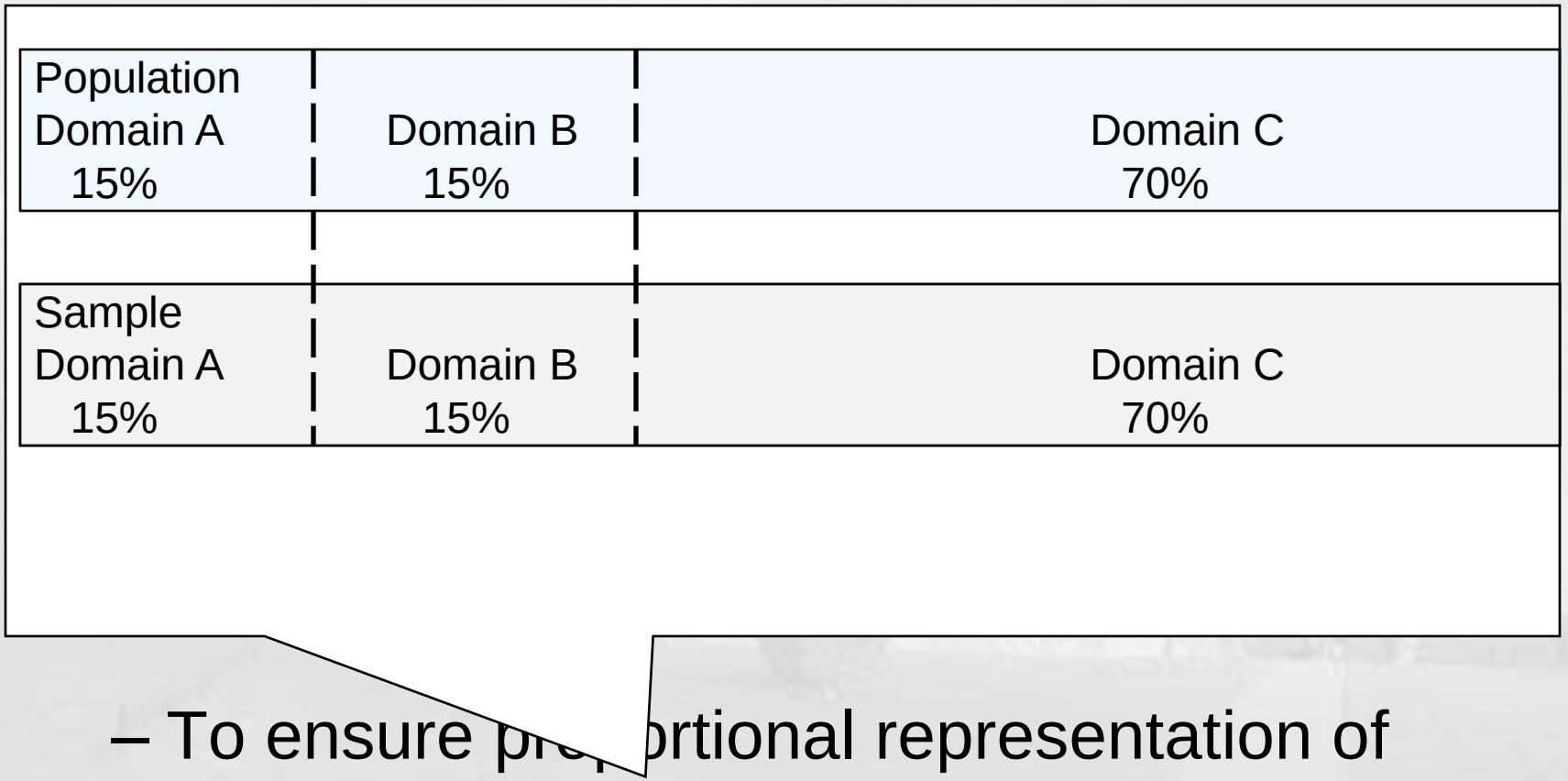
Sampling Frame

Other aspects to consider in defining the international desired target population

- Feasibility
  - Costs, time, resources
- Overlapping with other studies

Sampling Frame

- Stratification : grouping of schools
  - To apply disproportionate sample allocation by domains (sub-groups)
    - More reliable domain estimates
  - To ensure proportional representation of specific groups in the sample
  - To improve the reliability of the overall survey estimates by forming homogeneous groups



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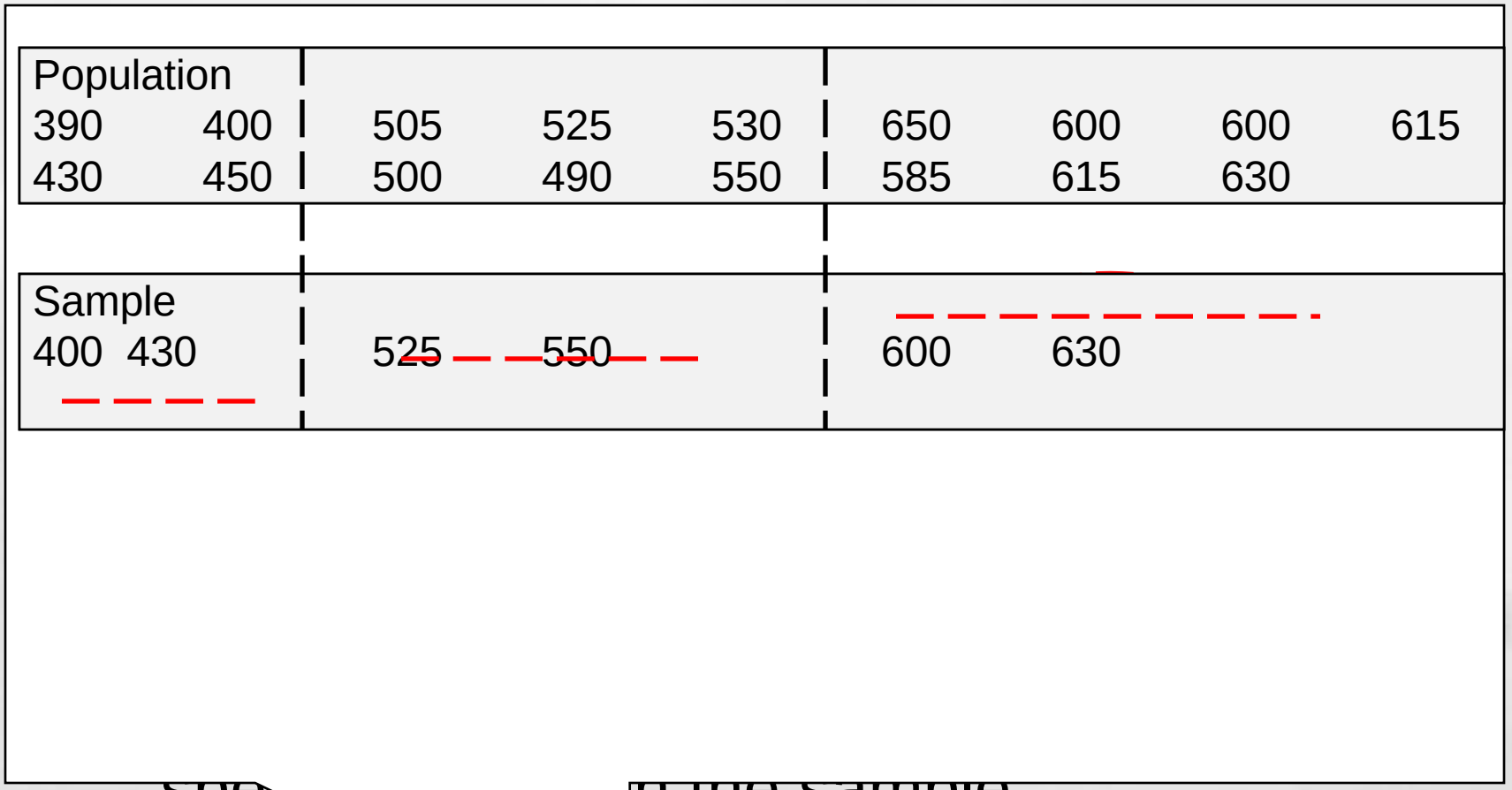


spec[illegible]n the sample

– To improve the reliability of the overall survey estimates by forming homogeneous groups

Sampling Frame

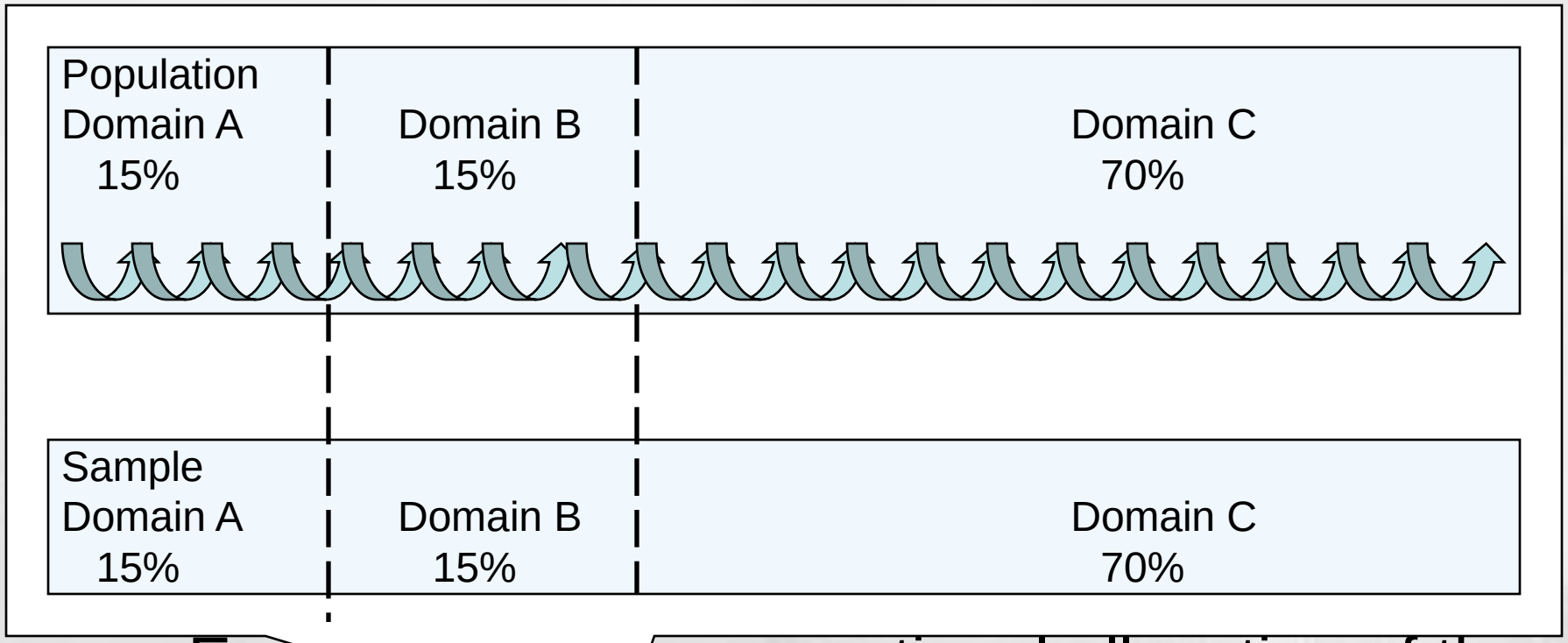
- Stratification variables
  - Variables defining domains of interest for which :
    - over sampling is required
    - proportional representation is required
  - Variables highly correlated to the school mean scores
  - Variables defining non-response adjustment cells

Sampling Frame

- Stratification guidelines
  - Avoid over-stratification
  - Two to four stratification variables are usually sufficient
  - Each school in the sampling frame must belong to one, and only one, stratum
  - A few divisions of a continuous variable is usually sufficient, i.e., 2 to 5
  - Avoid defining very small strata
  - Sample at least two schools per stratum

Sample Selection Method

- Explicit stratification
  - Consists of building separate school lists according to a set of explicit stratification variables
  - Implements a disproportionate sample allocation to produce more reliable estimates by explicit stratum



– Ensure[illegible]y proportional allocation of the school sample across all implicit strata

Sample Selection Method

Stratified multi-stage PPS systematic sampling (cluster sampling)

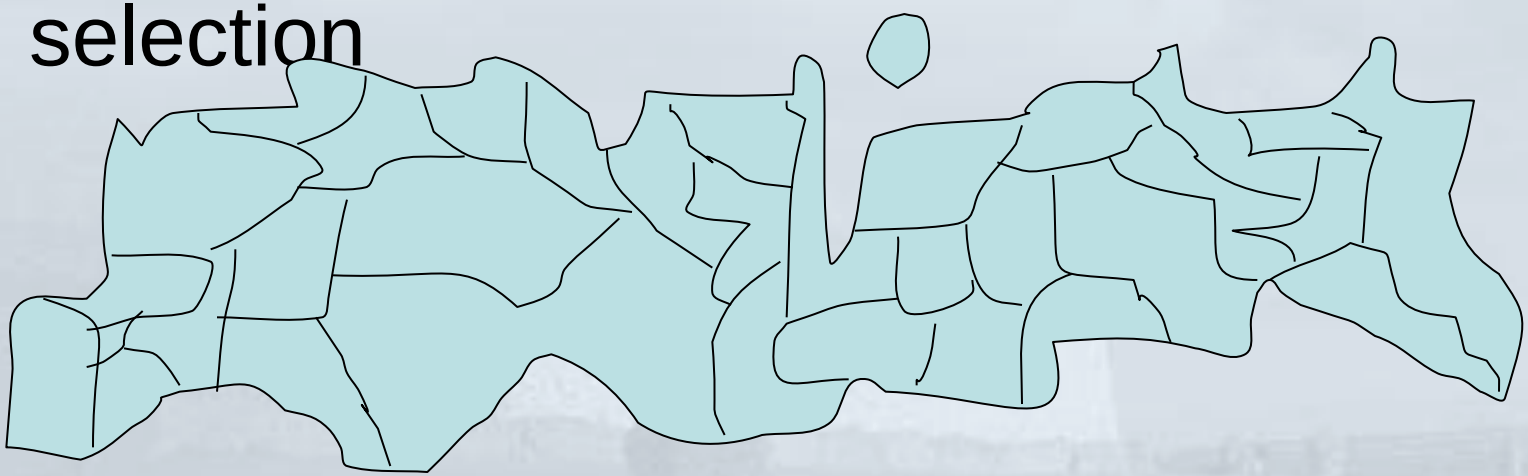
- School sampling
  - Description of the process
    - Multi-stage, PPS, systematic
  - Replacement schools
- Within-School sampling

School Sampling

- Multi-stage sampling (clustered sampling)
  - Sample of schools is first drawn (PSU)
  - Within selected schools, a sample of classes (teachers) could then drawn,
  - Within selected classes, a sample of (usually all) students is chosen
- Within explicit strata, PSUs are selected in a systematic way (random start) by opposition to have each PSU chosen randomly

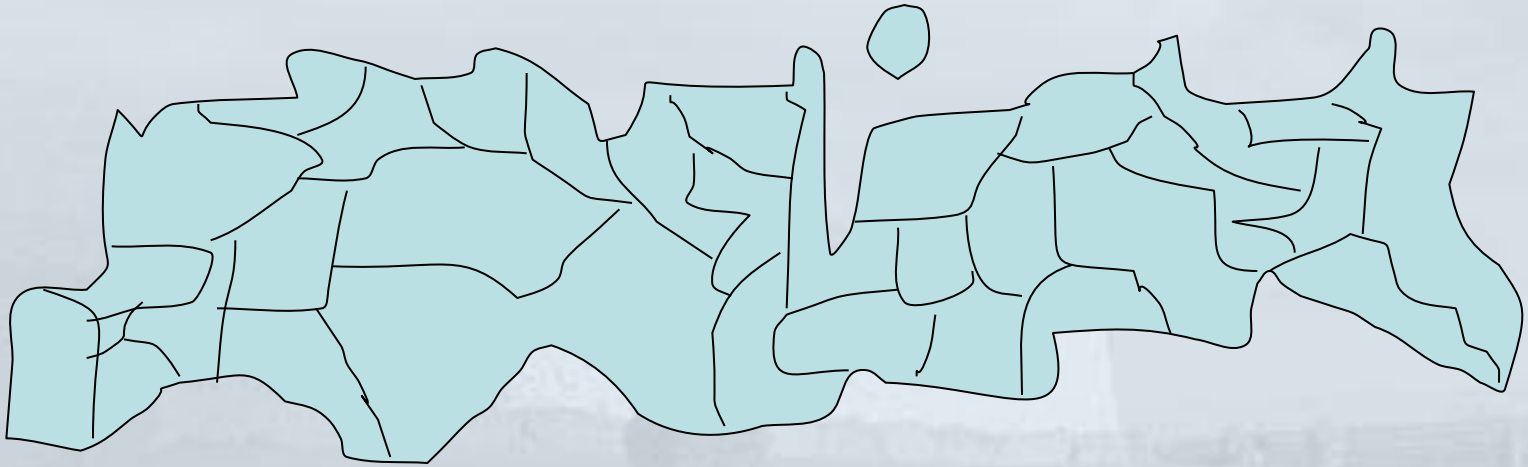
School Sampling

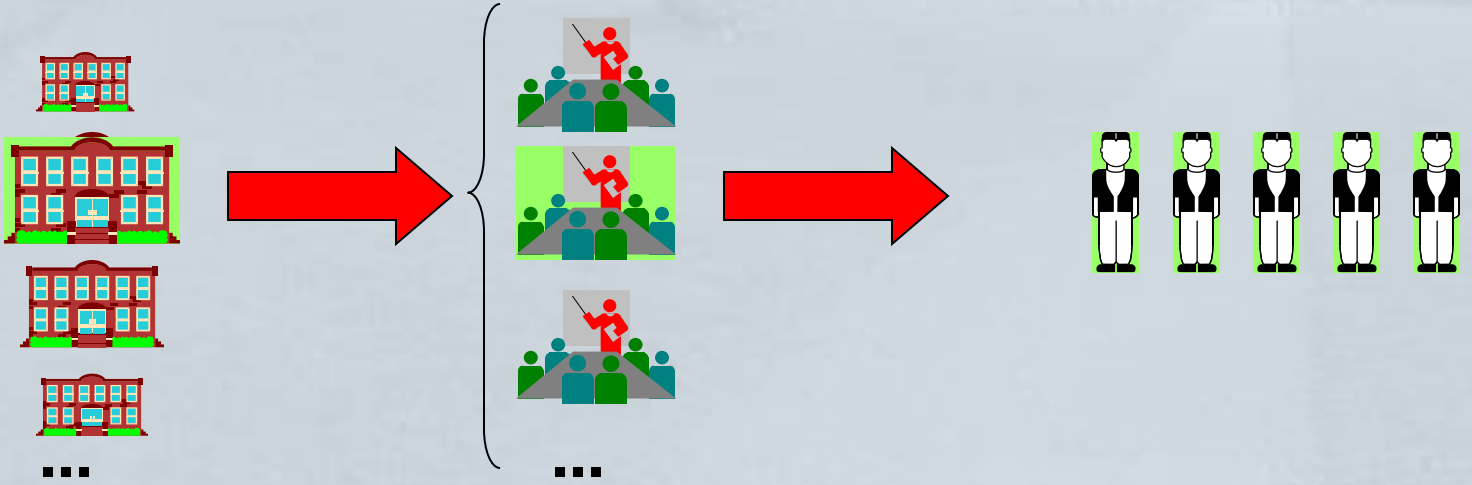
Multi-stage stratified cluster sample selection



School Sampling

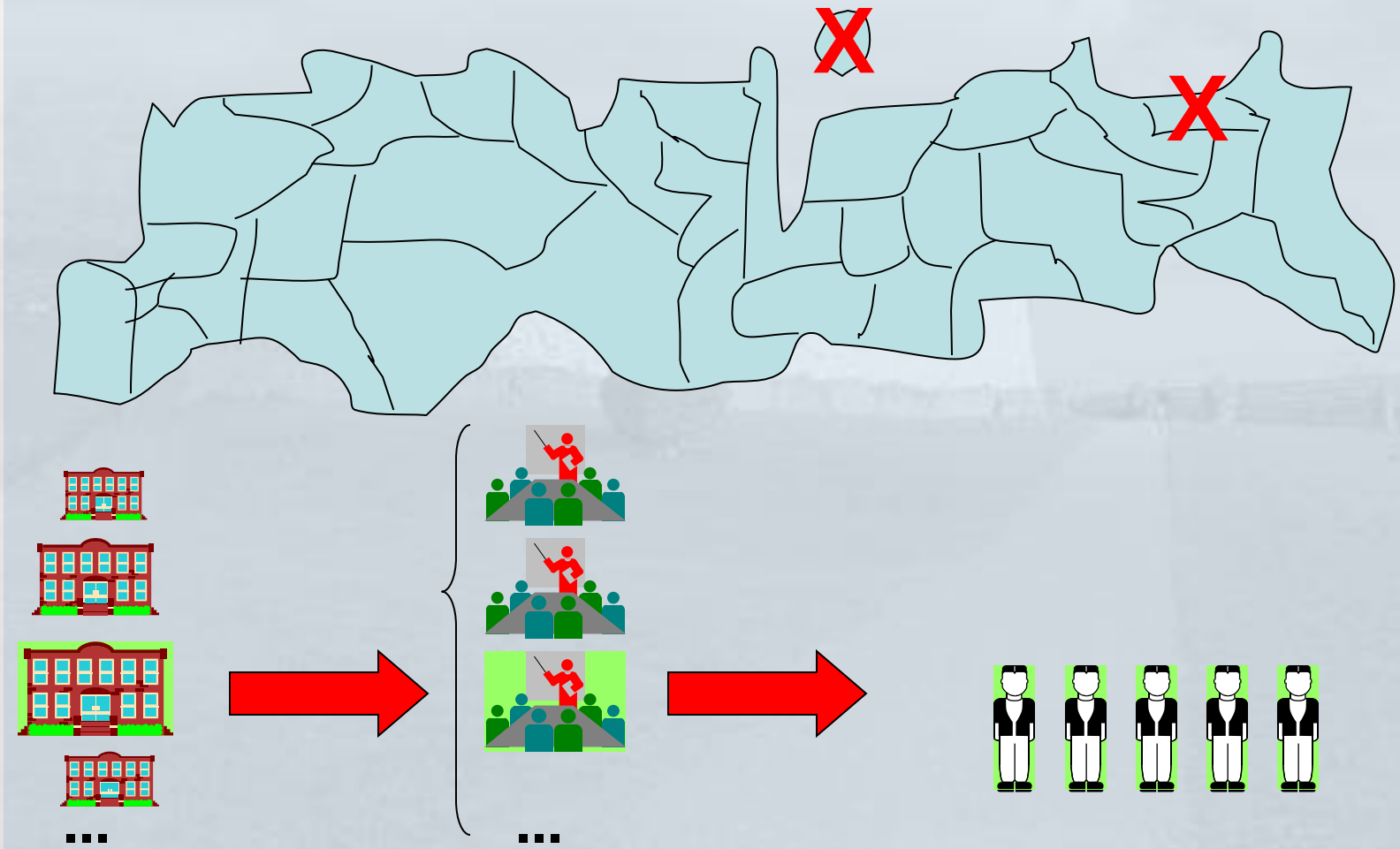
Multi-stage





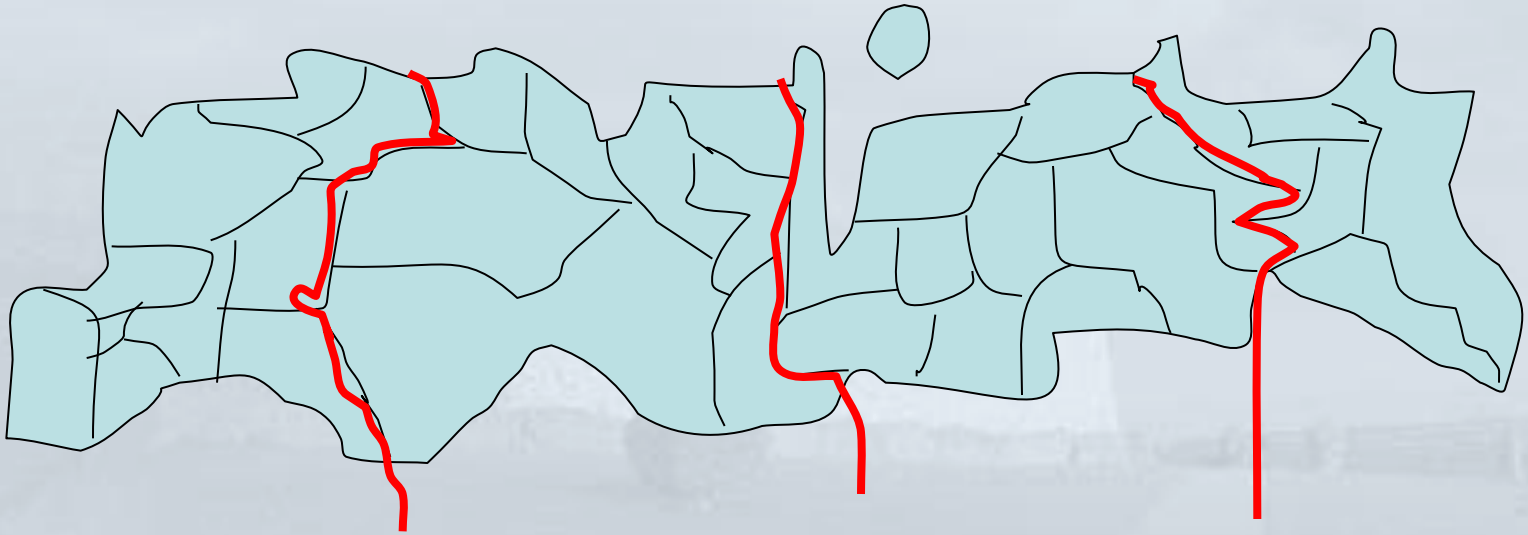
School Sampling

Multi-stage



School Sampling

Multi-stage stratified



Stratification consists of grouping schools into strata

Examples: Regions, zones, urbanization, socio-economic status, school types

School Sampling

- Probability proportional to size (PPS) sampling
  - IEA's usual approach

  PSUs (schools) are selected with probability proportional to their size

  - A measure of size (MOS) is required for each first stage sampling unit (PSU)

School Sampling

PPS sampling:

- The larger the school, the bigger the chance to sample it
- Very large schools are automatically (always!) in
  - Perception of a good sample
  - Important response burden for the schools but not for the students within these schools
- Gain in reliability (when the size of the school is correlated to the characteristic of interest)

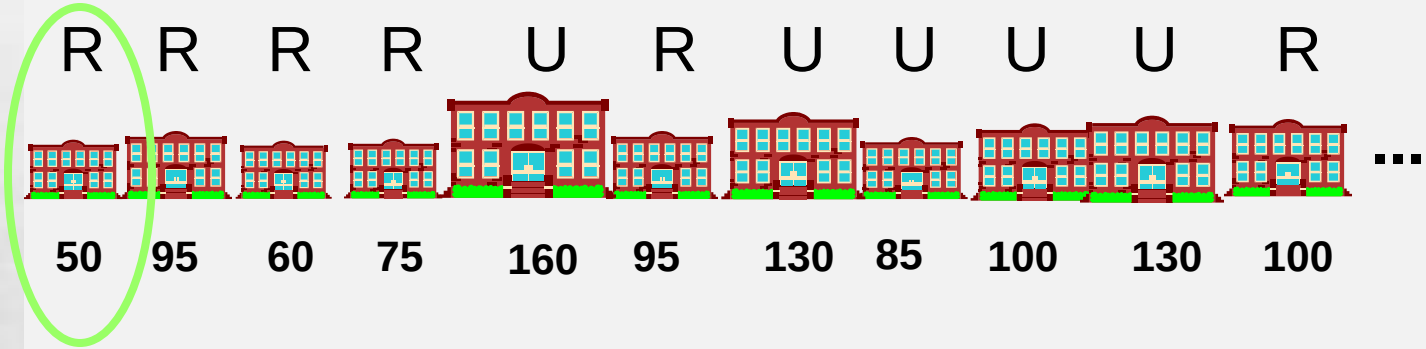
School Sampling

PPS sampling:

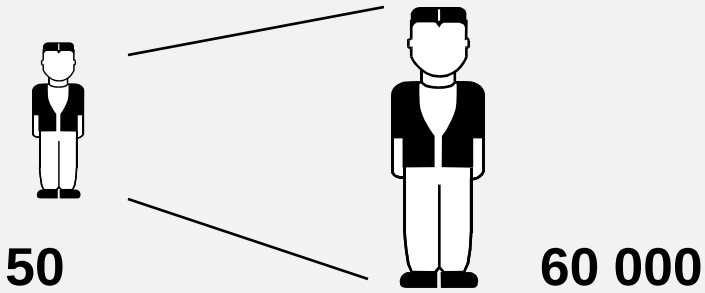
- Tends to produce equal sampling probabilities at the ultimate level (students, teachers) for units belonging to the same stratum (when the same number of classes (teachers) is sampled within each school)
- Small schools are selected with equal probability however
  - The measure of size is too unstable

School Sampling

PPS school sampling



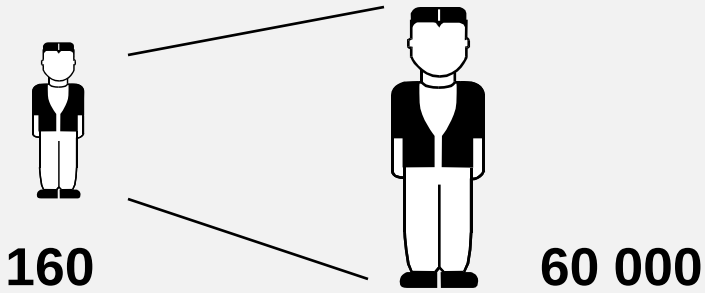
If PPS is used to select one school out of 1000 schools (for a total of 60 000 students) then that school has MOS chances out of 60 000 of being selected. In this example, the 50 sampled students would represent the 60 000 found in the population



School Sampling

PPS school sampling

If this school is selected however, then the 160 sampled students would represent the 60 000 found in the population



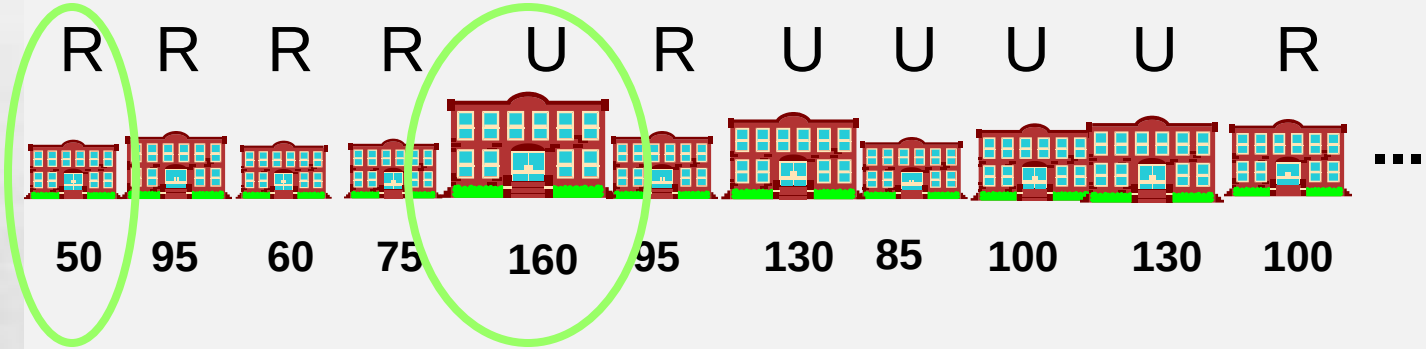
School Sampling

PPS sampling

- Selection with PPS produces a sample in which each selected units (school) represent the same number of elements (students) in the population. Thus if you are selecting 2 schools from a population of 60 000 students, each selected school represents 30 000 students.

School Sampling

PPS school sampling



30 000 **30 000**

SRS : 2 schools out of 1000

500 X 50 **500 X 160**

25 000 **80 000**

School Sampling

Replacement schools

- Two replacement schools are assigned to each original selected school (when possible)
  - One replacement for the Field Test
- Attempt to reduce the risk of bias without reducing the sample size too much
  - Has to be documented
  - Can’t choose your own replacements

School Sampling

Replacement schools

- Only refusals can be replaced
- Nothing is better than the original schools (possible bias)
- A priori identification of replacement schools is the standard approach in IEA studies (sizes & characteristics)
- Usually no substitution is allowed past the first stage sampling (schools)

School Sampling

Replacement schools

- Participation Rates (Standards)

Minimum school participation rate of 85%

Minimum classroom participation rate of 95%

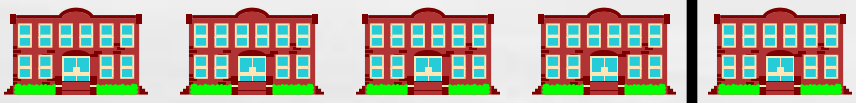
Minimum student participation rate of 85%

OR

Minimum overall participation rate of 75%

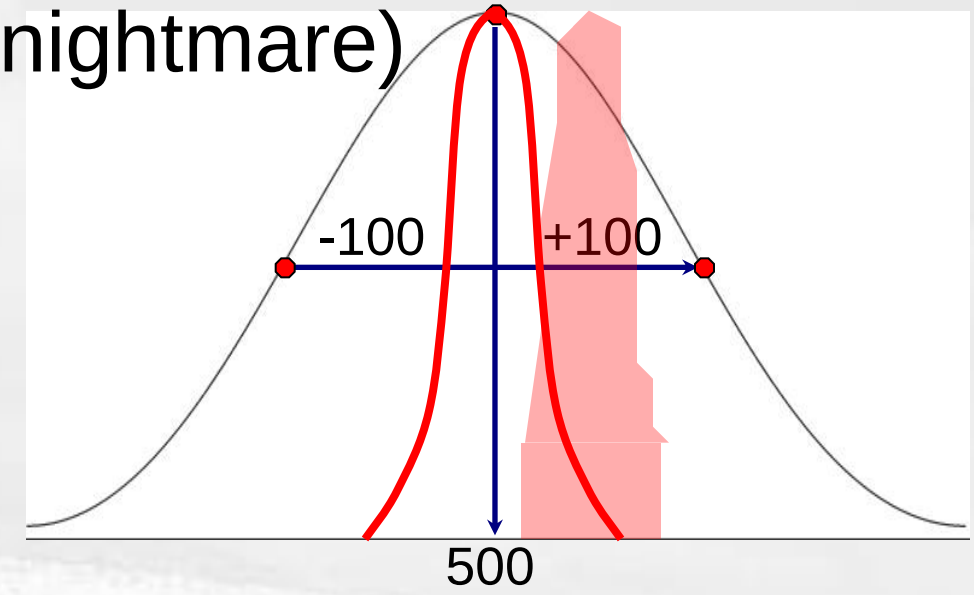
Bias effects (sampler nightmare)

Pop: M=500
S=100



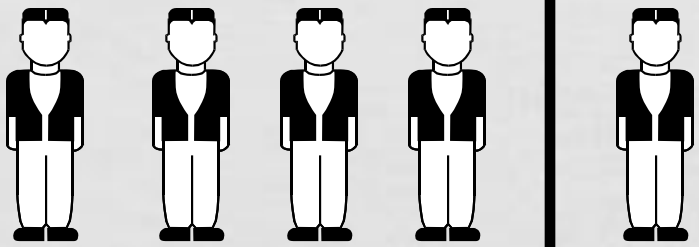
80% response rate

M = 480



M = 505

M = 509



M = 490

80% resp. rate

Bias effects (sampler nightmare)

Pop: M=500 S=100

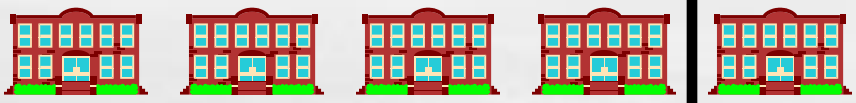
Sample: Standard error of the mean = 5

Confidence levels by bias scenarios

Sch–Std-Total resp. rates %	10 pts drop		20 pts drop		30 pts drop	
	m	level	m	Level	m	Level
100-100-100	500	95%	500	95%	500	95%
95-95-90	501	94%	502	93%	503	90%
90-90-81	502	93%	504	86%	507	73%
85-85-72	504	89%	507	71%	511	44%
80-85-68	504	86%	509	60%	513	27%
75-85-64	505	83%	510	47%	515	14%
70-85-60	506	77%	512	32%	518	5%

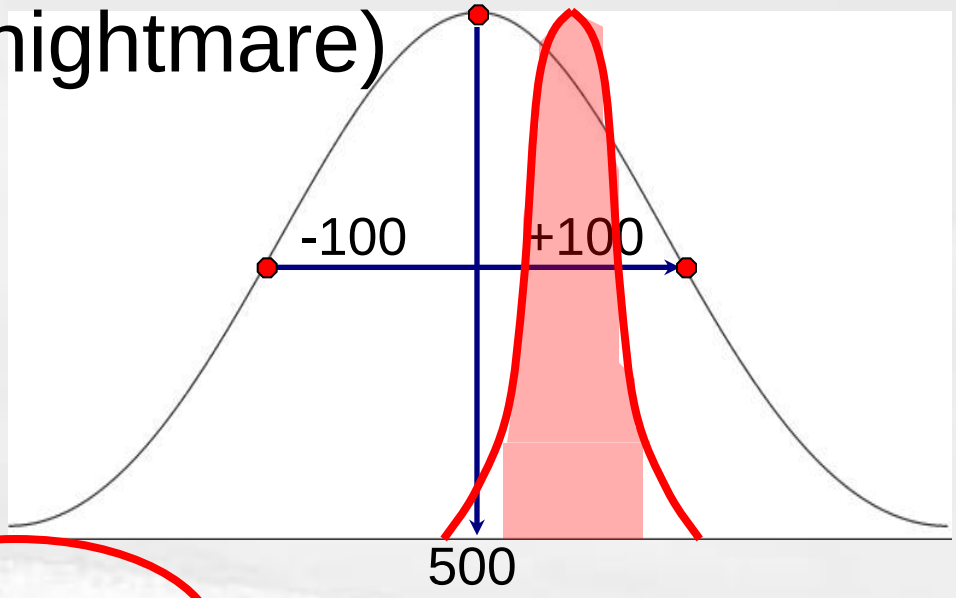
Bias effects (sampler nightmare)

Pop: M=500
S=100



80% response rate

M = 480



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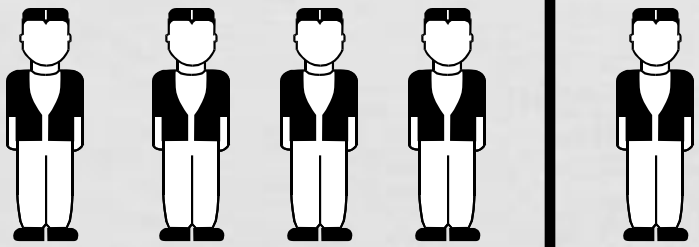


M = 490

80% resp. rate

School Sampling

- Within school sampling
  - Whenever possible, class selection is recommended (students)
  - When possible, ‘take all’ approach should at least be considered (teachers)
  - Substitution should not be allowed
  - Participation rates should be set high
  - Exclusions should be clearly identified prior to sampling (and kept to a minimum)

Sample Size

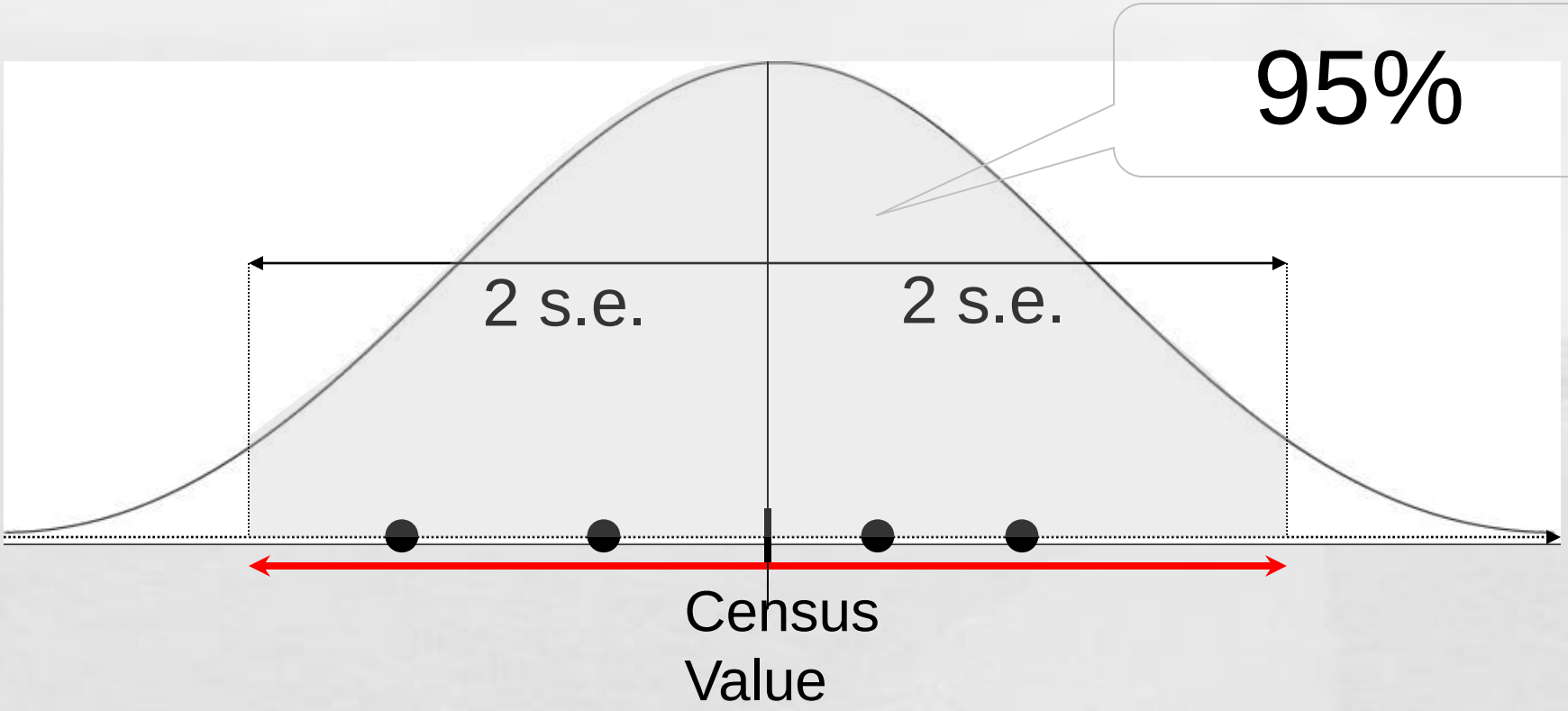
IEA International Standards:

- An effective sample size resulting in the following 95% confidence limits for sample estimates of population
  - MEANS: m ± 0.1s (s being the population standard deviation)
  - PERCENTAGES: p ± 5%
  - CORRELATIONS: r ± 0.1
- This is equivalent to a simple random sample of 400 units

Sample Size

A 95% confidence interval can be described as follows:

If sampling is repeated indefinitely, each sample leading to a new confidence interval, then in 95% of the samples the interval will cover the true population value (G.W. Snedecor, W G. Cochran)


95%
2 s.e.
2 s.e.
Census
Value

Sample Size

Factors to consider:

1. Data requirements (levels & precision)
2. Sample plan

Sample Size

Factors to consider:

1. Data requirements (levels & precision)
2. Sample plan

$$\text{Design effect} = \frac{\text{Variance under current design}}{\text{Variance under a SRS}}$$

- Estimates of design effects (intraclass correlation coefficients) are usually derived from previous studies

Sample Size

Factors to consider:

1. Data requirements (levels & precision)
2. Sample plan

$$\text{Margin of error} = 2 \text{ x } S\sqrt{\frac{\text{Deff}}{n}}$$

- Where n gives the student sample size
- Deff of 5 and standard deviation of 100 are usually assumed for new countries

Sample Size

Factors to consider:

1. Data requirements (levels & precision)
2. Sample plan

- Margin of error is inversely proportional to the square root of the sample size
- For example, if 150 schools give a 7 points margin of error than under a similar design effect, 35 to 40 schools will buy you a 14 points margin.
- For reasonably stable domain estimates, a sample size of at least 30 schools is preferable.

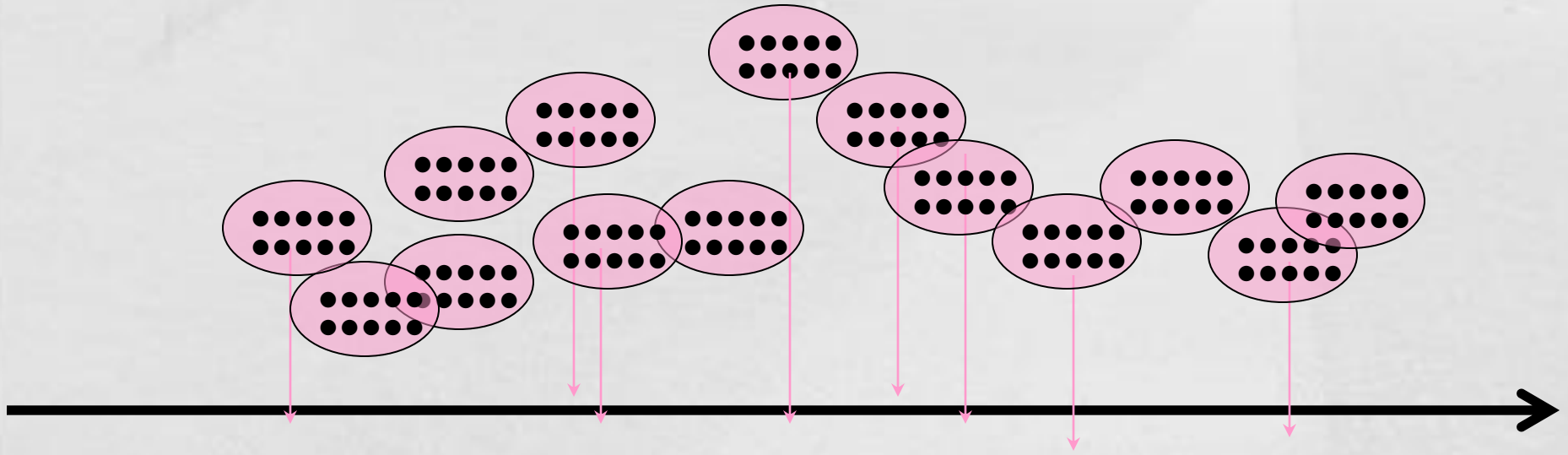
List of schools

Domain A	Domain B	Domain C
10%	10%	80%

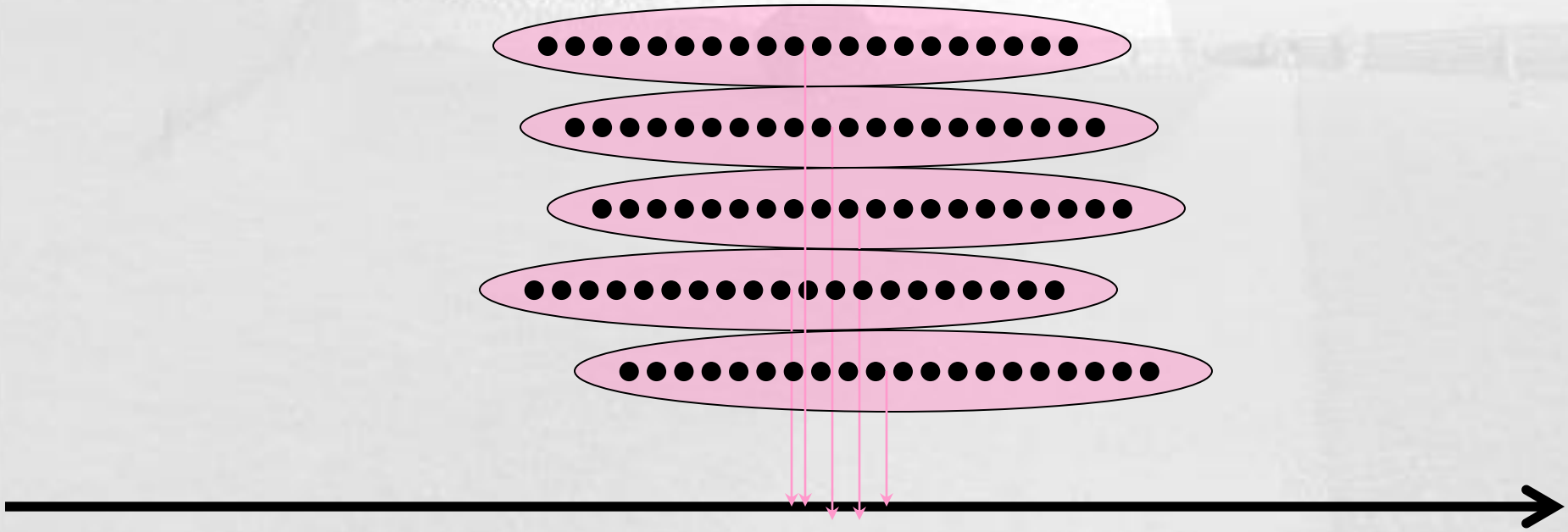
Sample of schools

Domain A	Domain B	Domain C
15 schools	15 schools	120 schools
+ 20	+20	

Large variation between schools combined with little variation within school =
High intraclass correlation coefficient



Little variation between schools combined with large variation within school = High intraclass correlation coefficient



Sample Size

Factors affecting sample sizes:

1. Data requirements (levels & precision)
2. Sample plan
3. Variability of characteristics in the population (Main variable(s) of interest)
4. Non-response
5. Cost and time (operational constraints)
6. Study constraints.
7. Size of the population

Sample Size

Sample allocation between strata

- When variability among units does not differ much from stratum to stratum and the same can be said about the collection costs, proportional allocation is usually recommended unless strata themselves are of principal interest

  Examples:

  - Regions are to be equally represented
  - Under allocation of very remote areas

Sample Size

Sample allocation between strata

POP:	90%	10%

4000 sampled units	Str 1 (M.E.)	Str 2 (M.E.)	Overall (M.E.)
Proportional allocation	3600 (10.5)	400 (31.6)	10
Equal allocation	2000 (14)	2000 (14)	12.8
IEA approach (min. fixed sizes)	3300 (11)	2000 (14)	10
Disproportional allocation	5400 (8.6)	100 (63)	10

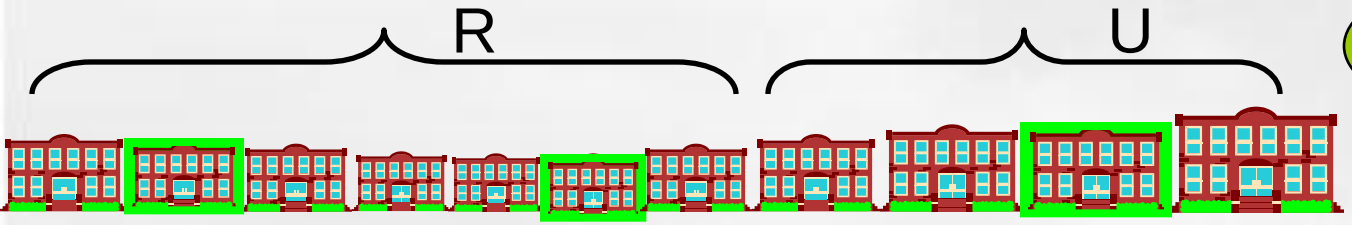
Sample Selection Method (Overview within explicit strata)

Sampling Steps

R R R R U R U R U U R ...

50 95 60 75 160 95 130 85 100 130 100 MOS

Sampling stages



100	95	95	75	60	50	85	100	130	130	160
	195	290	365	425	475	560	660	790	920	1080

MOS

Cumulative **MOS**

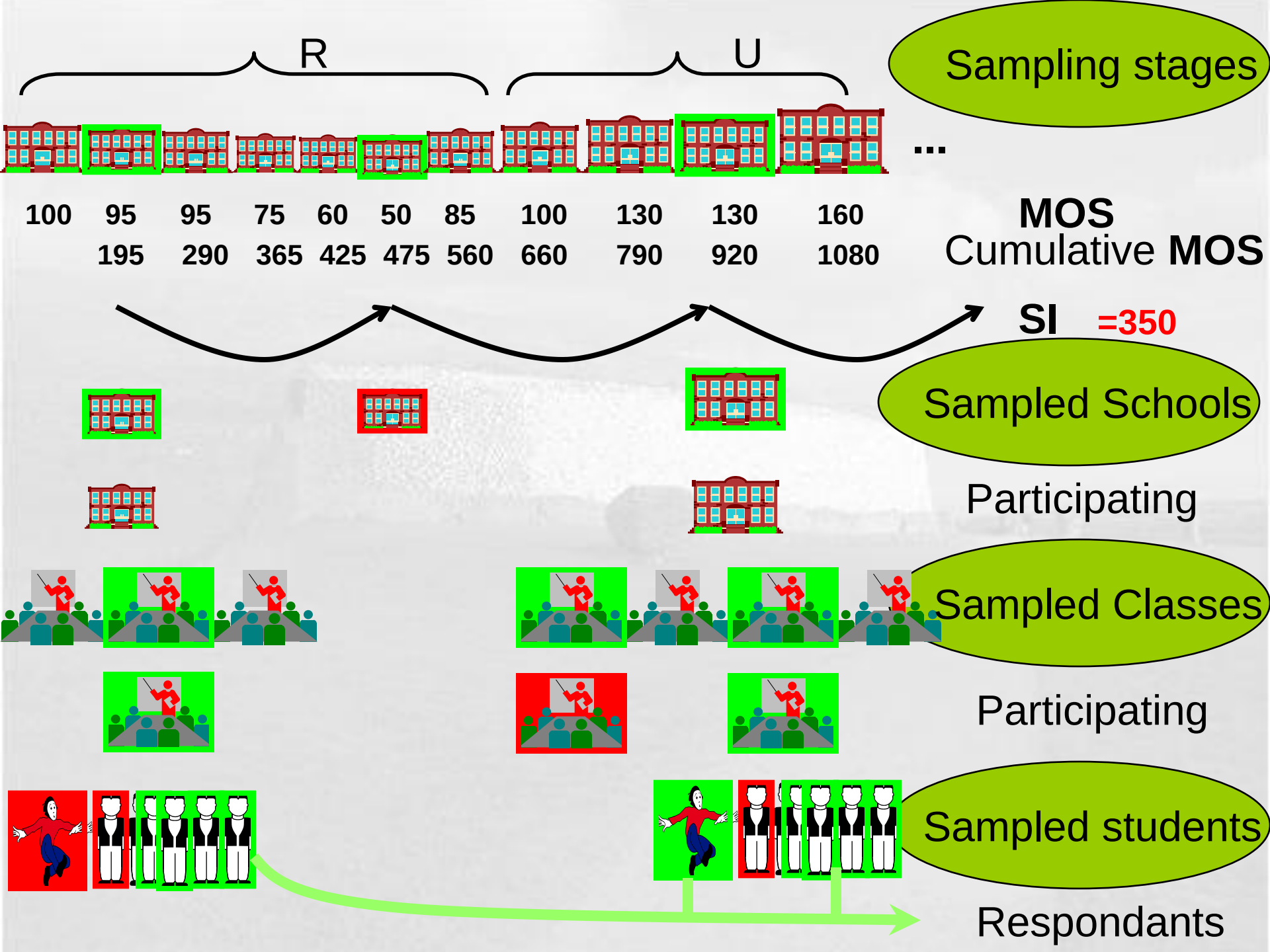
SI **=350**

Sampled Schools

Respondent schools

Warning:

Schools with no targeted students, with only excluded students, or closed schools are not replaced


R
U
Sampling stages
...
100 95 95 75 60 50 85 100 130 130 160
MOS
195 290 365 425 475 560 660 790 920 1080
Cumulative MOS
SI =350
Sampled Schools
Participating
Sampled Classes
Participating
Sampled students
Respondants

Sample Design

Why do we need one?

- To make sure each unit of the “effective” target population has a known probability of being in the sample
- To make sure we know how to compute this probability
- To allow for UNBIASED mean and standard error estimates about the “effective target population”
- To get an estimate of the level of coverage.

Element of a Sample Plan

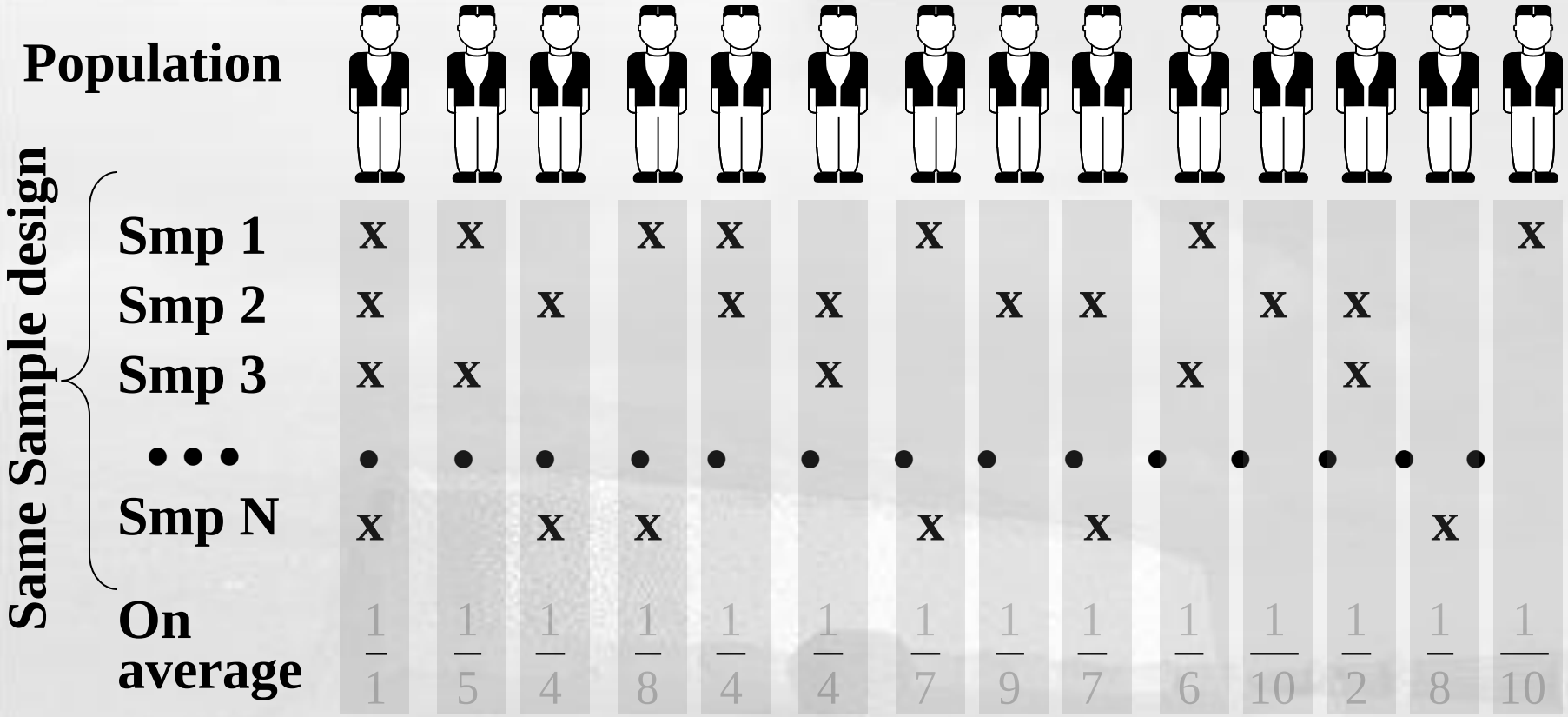
Estimation procedures

- Sampling weights
  - What are they?
  - Why using them?
    - An example

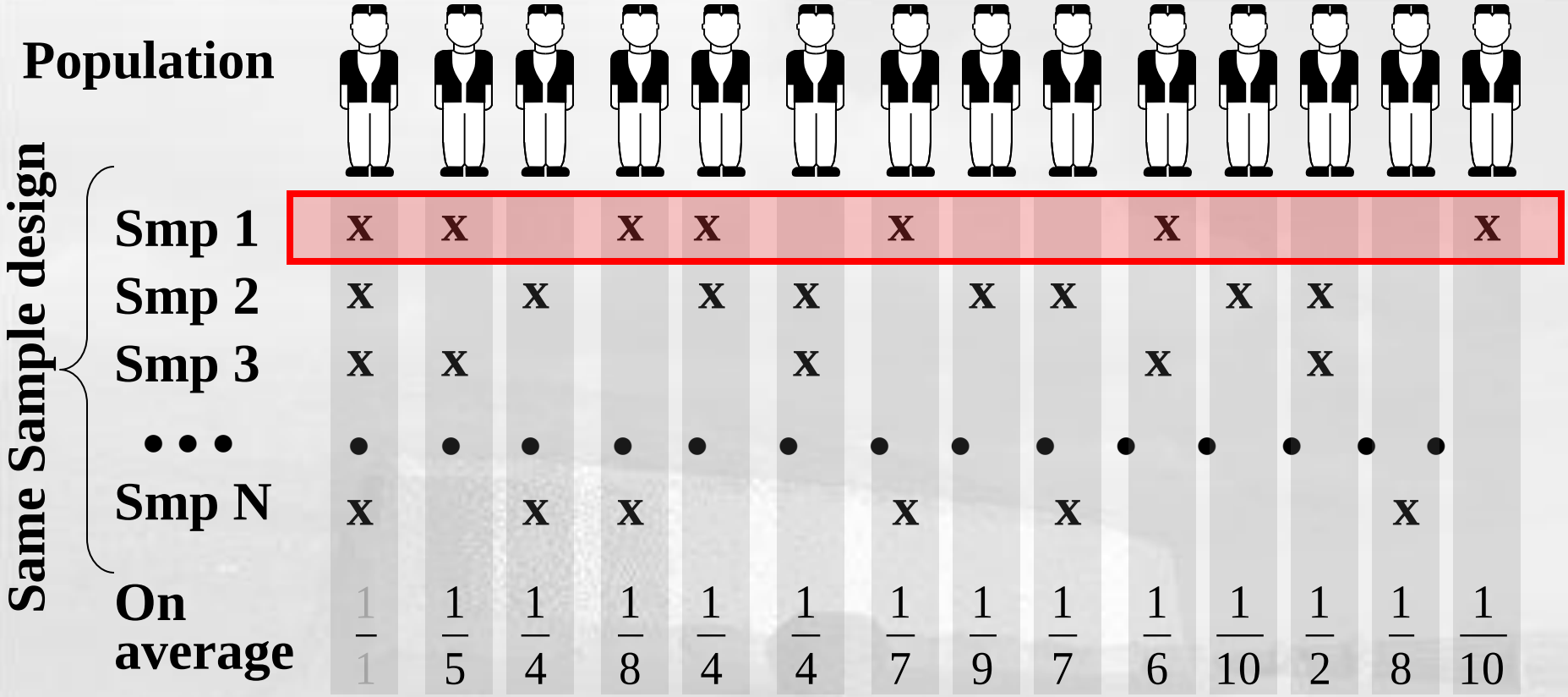
Estimation Procedures

Sampling weights (What are they?)

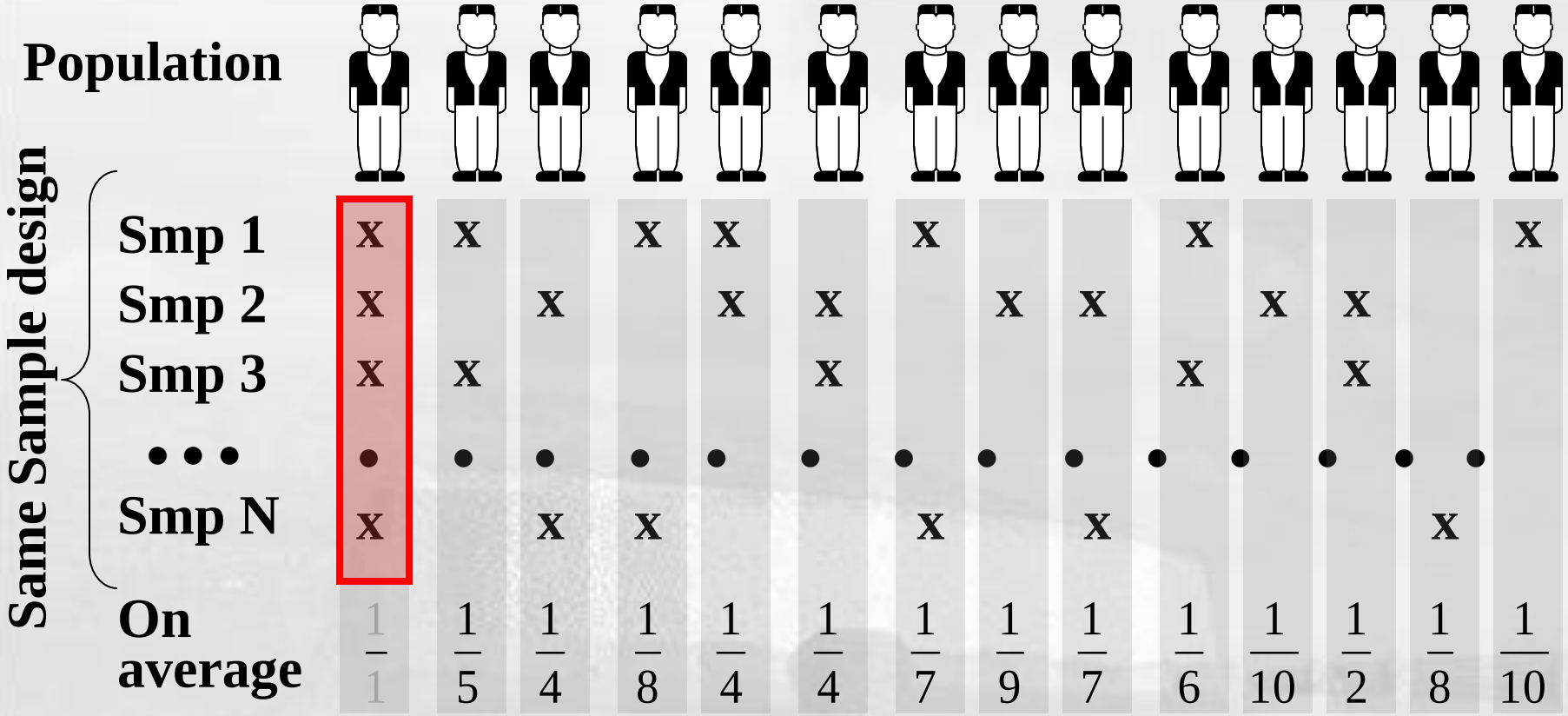
- Values assigned to all sampling units
- Based on the selection probabilities applied at each sampling stage
- Adjusted to take into account non response



- The number of times students are selected differs. This is usually the case!
  - Sample design (stratification, MOS over time, etc)
  - Non response

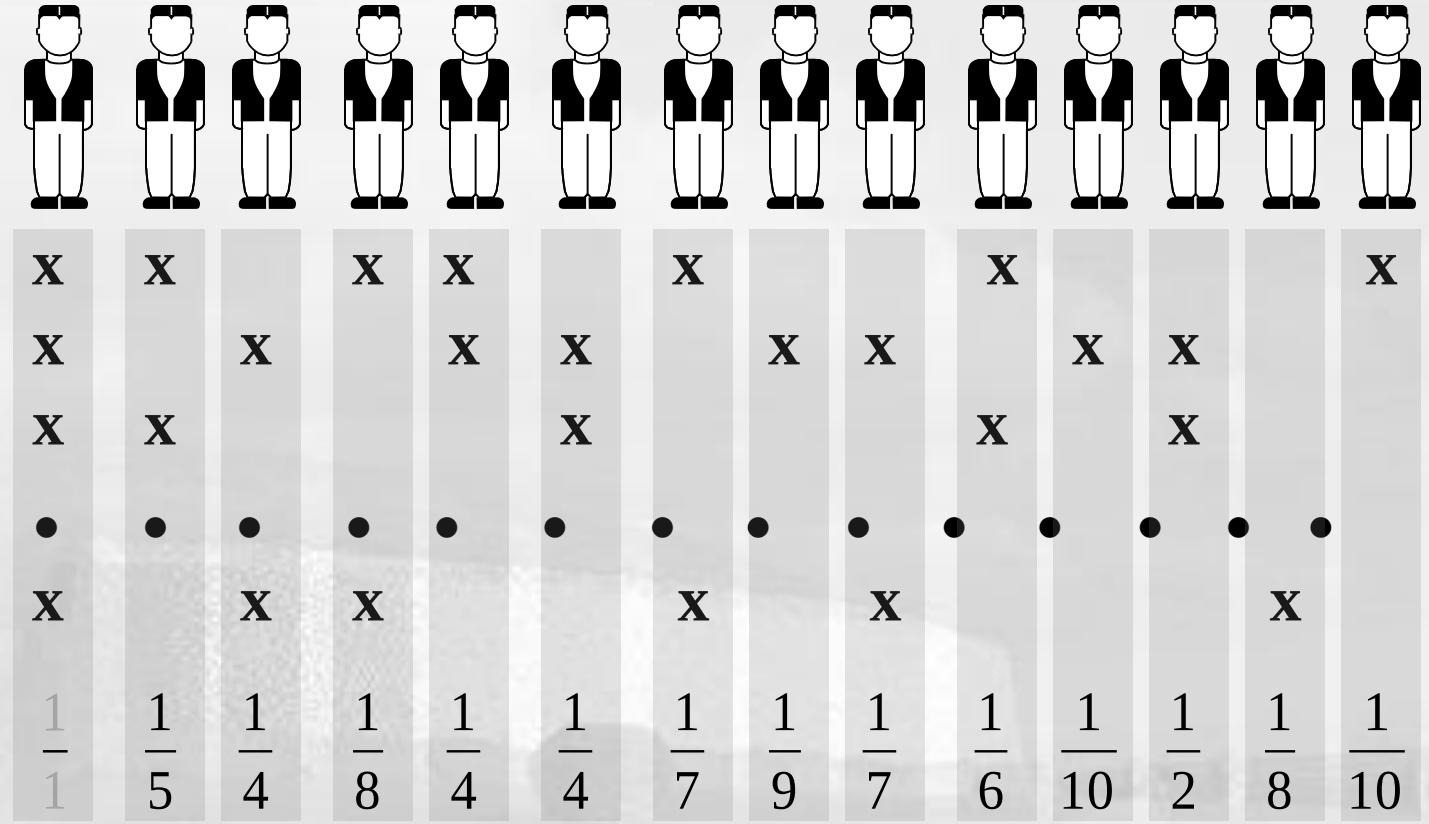


- Sample estimates ≠ Census estimates for all variables of interest

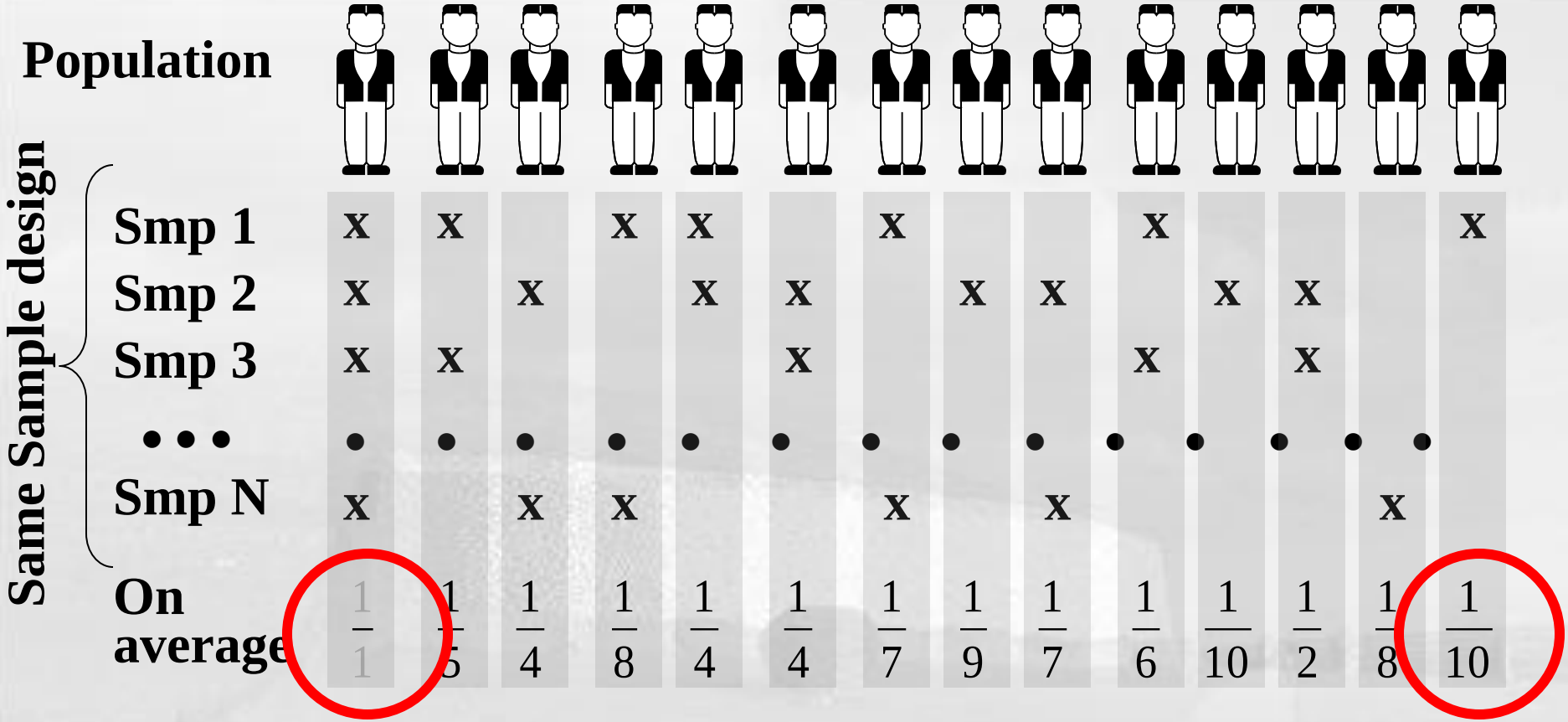


- However, on average we have the following relation for any variable of interrest:

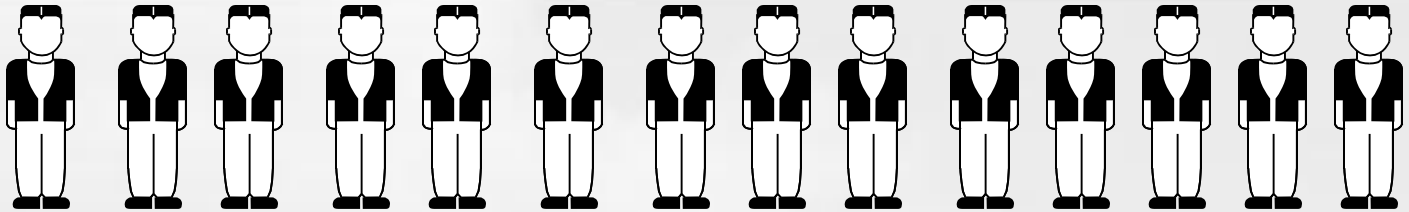
$$\sum_{\text{all samples}} \frac{\text{Weighted sample estimates}}{\text{Total number of samples}} = \text{Census value}$$



- Using sampling weights compensates for the fact that some units are selected more often.
- On average over all possible samples, all units have the same importance (as for a census)



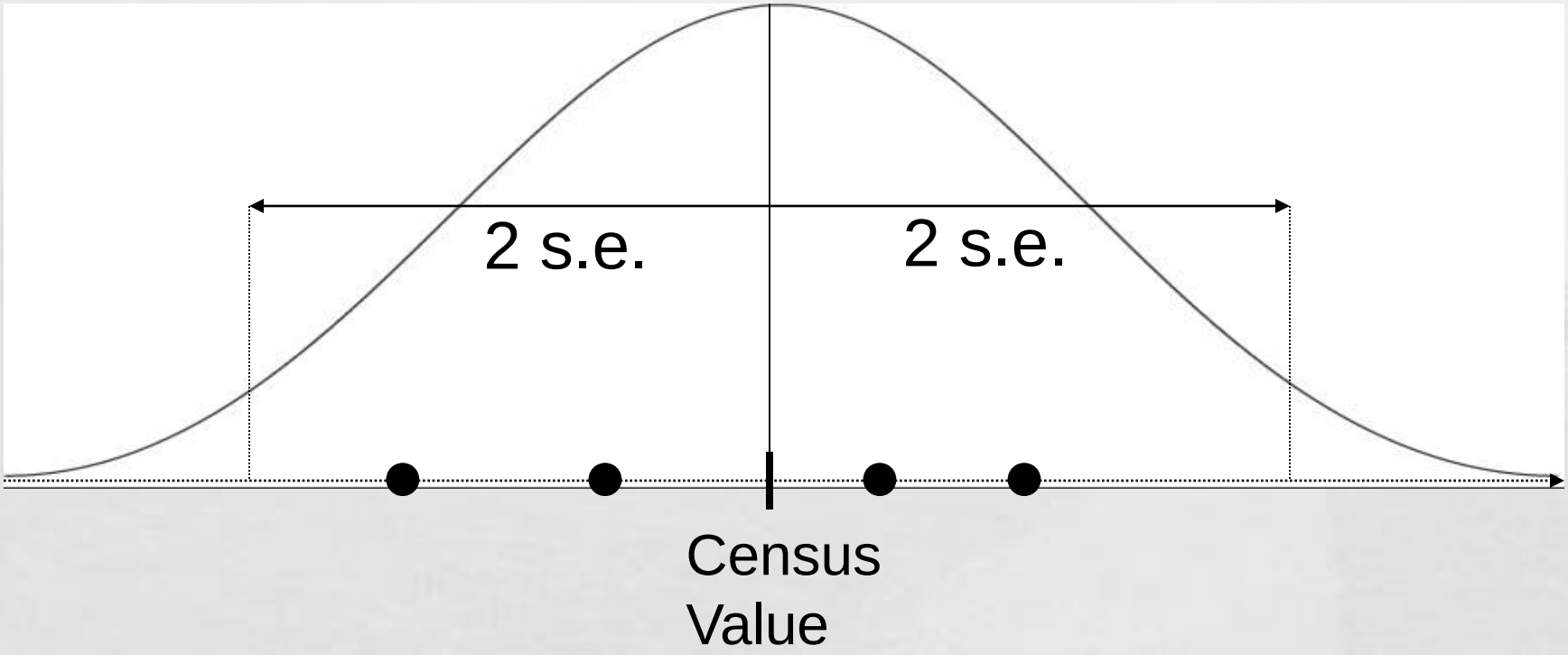
- Not using sampling weights gives more importance (weight!) to those students selected more often over all samples.

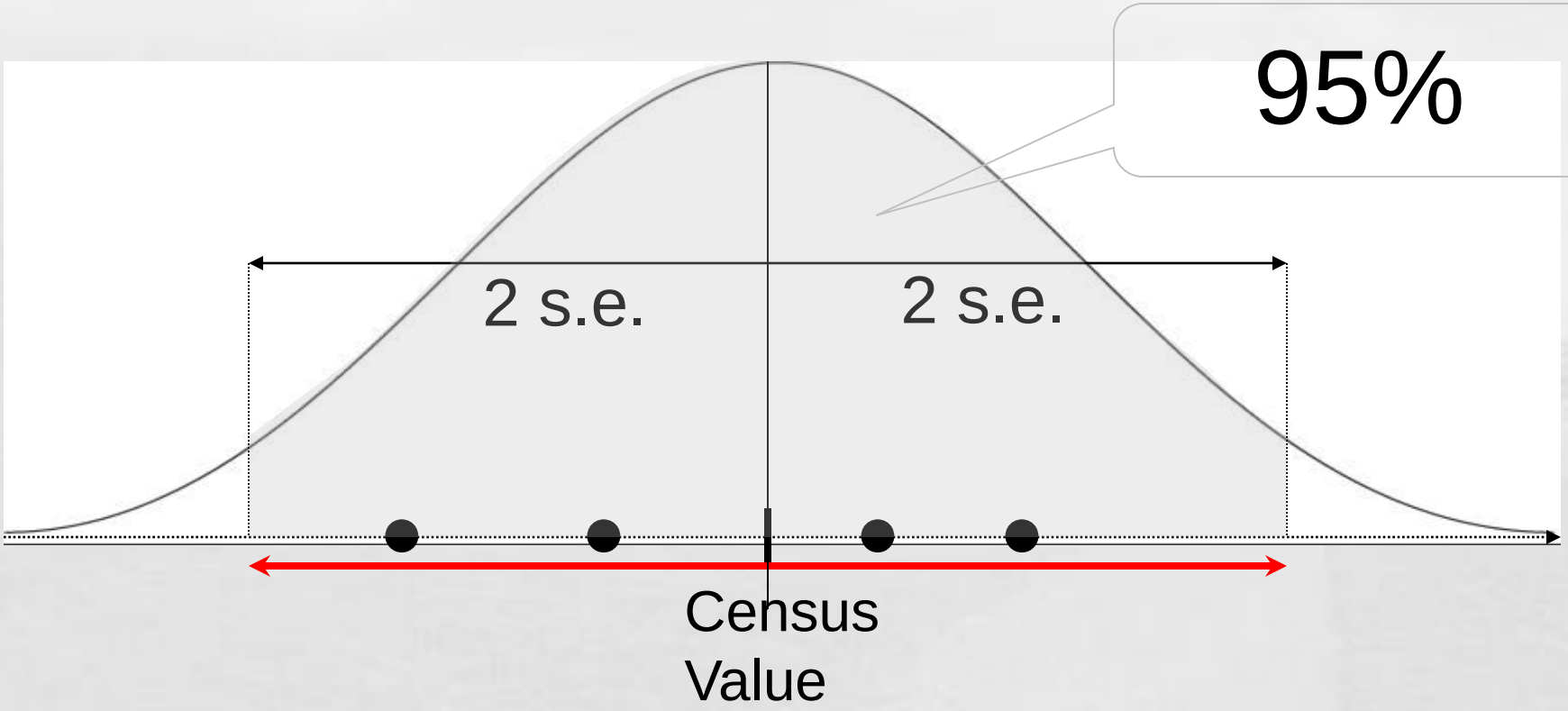


Same Sample design	Population														
	Smp 1	x	x		x	x		x			x				x
	Smp 2	x		x		x	x		x	x		x	x		
	Smp 3	x	x				x				x		x		
	• • •	•	•	•	•	•	•	•	•	•	•	•	•	•	•
	Smp N	x		x	x			x		x				x	
	On average	$\frac{1}{1}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{4}$	$\frac{1}{7}$	$\frac{1}{9}$	$\frac{1}{7}$	$\frac{1}{6}$	$\frac{1}{10}$	$\frac{1}{2}$	$\frac{1}{8}$	$\frac{1}{10}$

- Not using sampling weights shifts survey estimates away from the corresponding census value by an amount that is unknown.

- **Using sampling weights provides…**
  - Unbiased estimates of population characteristics


2 s.e.
2 s.e.
Census
Value


95%
2 s.e.
2 s.e.
Census
Value

Sampling Weights

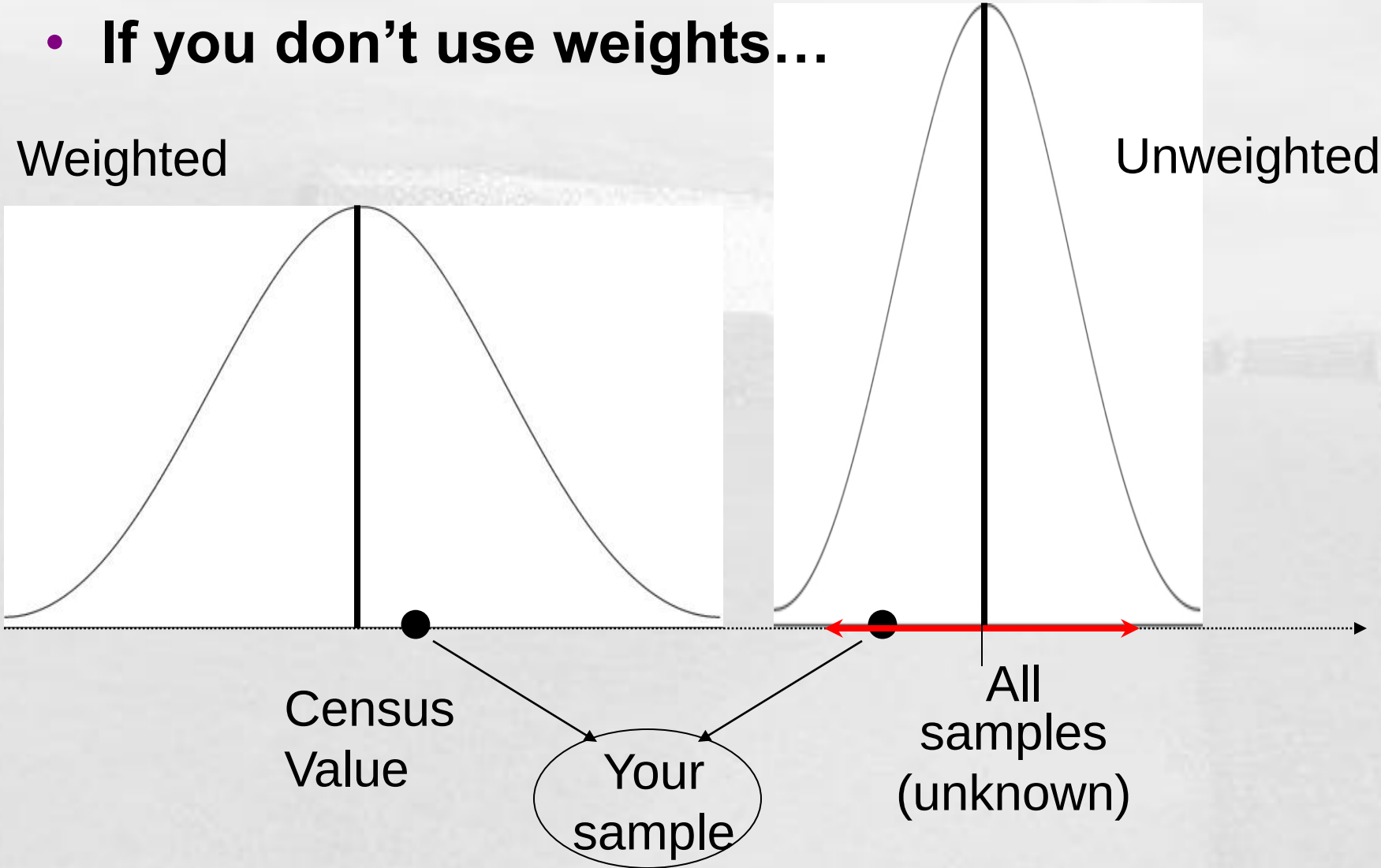
- **Why?**

  Using sampling weights:

  - Produce unbiased statistic estimates from the sample (equal to census statistics on average).
  - Produce reliable estimates of standard error for these statistics (tells us how much confidence one can have in sample statistics to reproduce census statistics from a particular sample).

Sampling Weights

- **If you don't use weights…**



In a perfect world (sampler universe)

60 (3 classes of 20 kids)

160 (8 classes of 20 kids)

...

SI =350

$$\frac{350}{60} \times \frac{3}{1} \times \frac{20}{20}$$

$$\frac{350}{160} \times \frac{8}{1} \times \frac{20}{20}$$

Third stage sampling

Quality standards

Documentation (A must!)

- Describe sampling methodology
- Describe sampling implementation
  - Coverage
  - Exclusion rates
  - Sample sizes
  - Participation rates

Field Test

- All efforts should be made to “field test” all sampling procedures
- Allows for a first glance at potential problems with the frame.

Target Population

Countries	Reading Achievement Distribution	Average Scale Score	Years of Formal Schooling*	Average Age	Human Development Index**
Italy		551 (2.9)	4	9.7	0.940
Hungary		551 (3.0)	4	10.7	0.869
Sweden		549 (2.3)	4	10.9	0.951
Germany		548 (2.2)	4	10.5	0.932
† Netherlands		547 (1.5)	4	10.3	0.947

I have good reasons to believe that the census value for this country is between 545 and 557 (551 ± 2 X 3.0)