Principles of Epidemiology for Public Health
EPID 160

Epidemiologic measures: Incidence & Prevalence

UNC School of Public Health
Department of Epidemiology
Summer 2002

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Famous last words

Quotations that demonstrate the value of humility about predicting the future (authenticity not established)

Courtesy of Suzanne Cloutier, 11/17/1998

“Louis Pasteur's theory of germs is ridiculous fiction.”

- Pierre Pachet, Professor of Physiology at Toulouse, 1872

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future

"This `telephone´ has too many shortcomings to be seriously considered as a means of communication. The device is inherently of no value to us."

- Western Union internal memo, 1876

(Source: 2000 National Ernst & Young Entrepreneur of the Year Awards special insert in *USA Today*, 2/11/2000, p9B)

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future

"Everything that can be invented has been invented."

- Charles H. Duell, Commissioner, US Patent Office, 1899

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future

"The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?"

- David Sarnoff's associates in response to his urgings for investment in the radio in the 1920s.

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future

The population perspective requires measuring disease in populations

- Science is built on classification and measurement.
- Reality is infinitely detailed, infinitely complex.
- Classification and measurement seek to capture the essential attributes.

Measurement “captures” the phenomenon

Classification and measurement are based on:

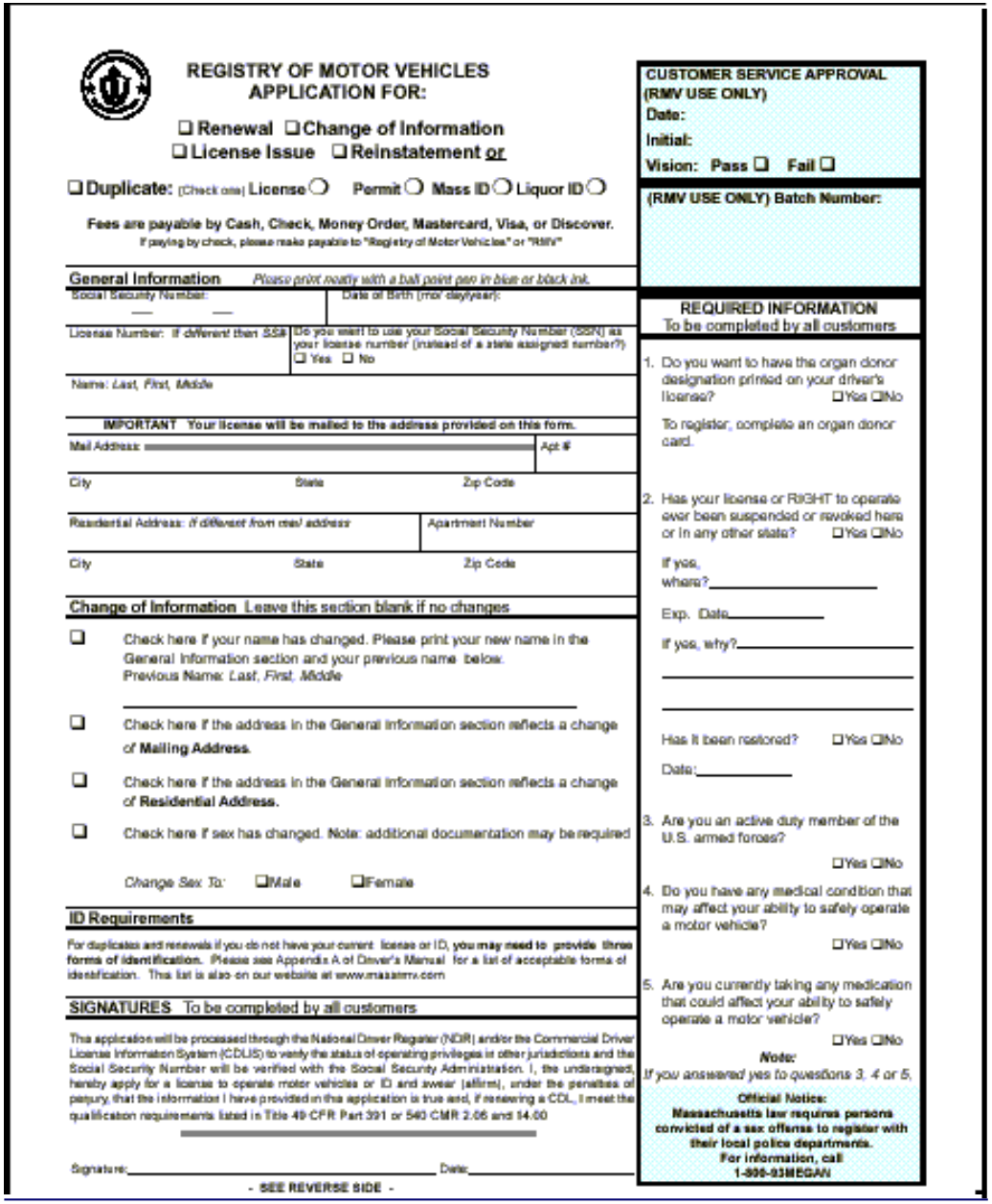
- Objective of the classification
- Conceptual model (understanding of the phenomenon)
- Availability of data (technology)

Example: Demographic Characteristics

Is sex a “fixed characteristic” or a “modifiable characteristic”?

That depends upon the objective, conceptual model, and technology!

-Massachusetts Registry of Motor Vehicles



REGISTRY OF MOTOR VEHICLES
APPLICATION FOR:

❑ Renewal ❑ Change of Information
❑ License Issue ❑ Reinstatement or

❑ Duplicate: (Check one) License ❍ Permit ❍ Mass ID ❍ Liquor ID ❍

Fees are payable by Cash, Check, Money Order, Mastercard, Visa, or Discover.
If paying by check, please make payable to "Registry of Motor Vehicles" or "RMV"

CUSTOMER SERVICE APPROVAL
(RMV USE ONLY)
Date:
Initial:
Vision: Pass ❑ Fail ❑

(RMV USE ONLY) Batch Number:

General Information *Please print neatly with a ball point pen in blue or black ink.*

Social Security Number: ___ ___
Date of Birth (mo/ day/year):
License Number: If different than SS#
Do you want to use your Social Security Number (SSN) as your license number (instead of a state assigned number?) ❑ Yes ❑ No
Name: *Last, First, Middle*

IMPORTANT Your license will be mailed to the address provided on this form.

Mail Address:
Apt #
City
State
Zip Code
Residential Address: *If different from mail address*
Apartment Number
City
State
Zip Code

Change of Information Leave this section blank if no changes

❑ Check here if your name has changed. Please print your new name in the General Information section and your previous name below.
Previous Name: *Last, First, Middle*

❑ Check here if the address in the General Information section reflects a change of **Mailing Address.**

❑ Check here if the address in the General Information section reflects a change of **Residential Address.**

❑ Check here if sex has changed. Note: additional documentation may be required

Change Sex To: ❑Male ❑Female

ID Requirements

For duplicates and renewals if you do not have your current license or ID, **you may need to provide three forms of identification.** Please see Appendix A of Driver's Manual for a list of acceptable forms of identification. This list is also on our website at www.massrmv.com

SIGNATURES To be completed by all customers

This application will be processed through the National Driver Register (NDR) and/or the Commercial Driver License Information System (CDLIS) to verify the status of operating privileges in other jurisdictions and the Social Security Number will be verified with the Social Security Administration. I, the undersigned, hereby apply for a license to operate motor vehicles or ID and swear (affirm), under the penalties of perjury, that the information I have provided in this application is true and, if renewing a CDL, I meet the qualification requirements listed in Title 49 CFR Part 391 or 540 CMR 2.06 and 14.00

Signature: Date:

- SEE REVERSE SIDE -

REQUIRED INFORMATION
To be completed by all customers

1. Do you want to have the organ donor designation printed on your driver's license? ❑Yes ❑No
To register, complete an organ donor card.

2. Has your license or RIGHT to operate ever been suspended or revoked here or in any other state? ❑Yes ❑No
If yes, where?
Exp. Date
If yes, why?
Has it been restored? ❑Yes ❑No
Date:

3. Are you an active duty member of the U.S. armed forces? ❑Yes ❑No

4. Do you have any medical condition that may affect your ability to safely operate a motor vehicle? ❑Yes ❑No

5. Are you currently taking any medication that could affect your ability to safely operate a motor vehicle? ❑Yes ❑No

Note:
If you answered yes to questions 3, 4 or 5,

Official Notice:
Massachusetts law requires persons convicted of a sex offense to register with their local police departments.
For information, call 1-800-93MEGAN

Changeable demographic characteristic ?

Change of Information Leave this section blank if no changes

❑ Check here if your name has changed. Please print your new name in the General Information section and your previous name below.
Previous Name: *Last, First, Middle*

_____

❑ Check here if the address in the General Information section reflects a change of **Mailing Address**.

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How can we quantify disease in populations?

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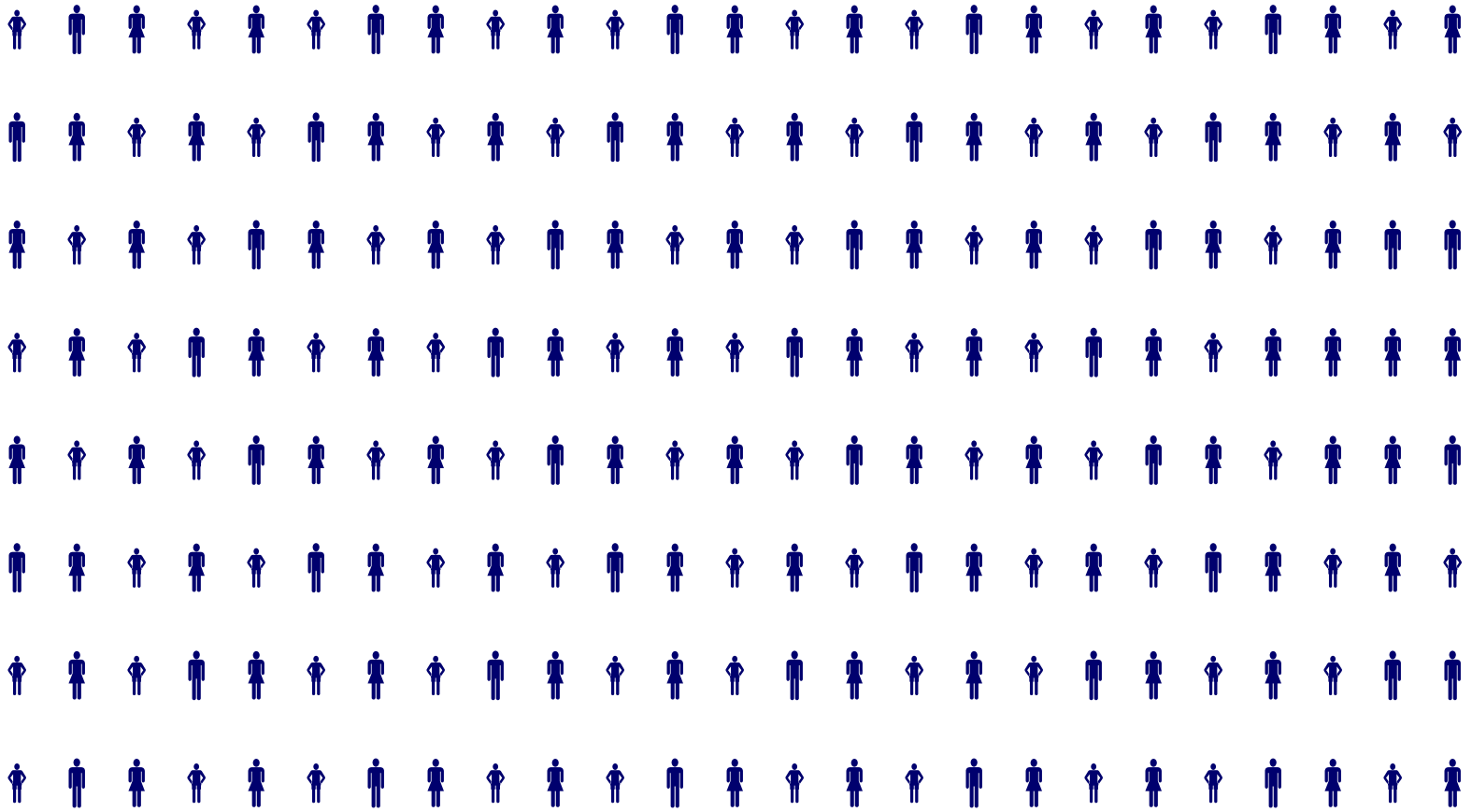

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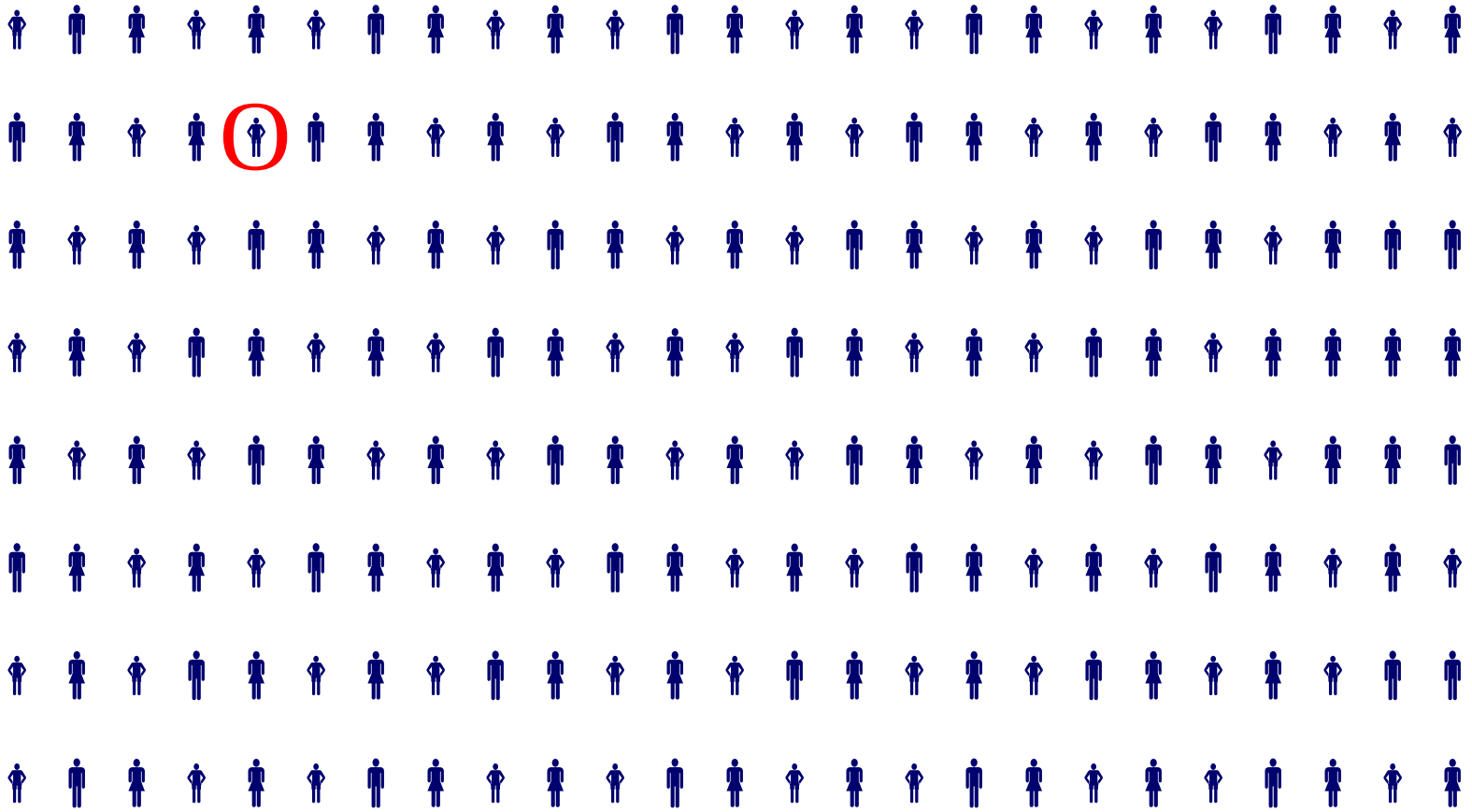

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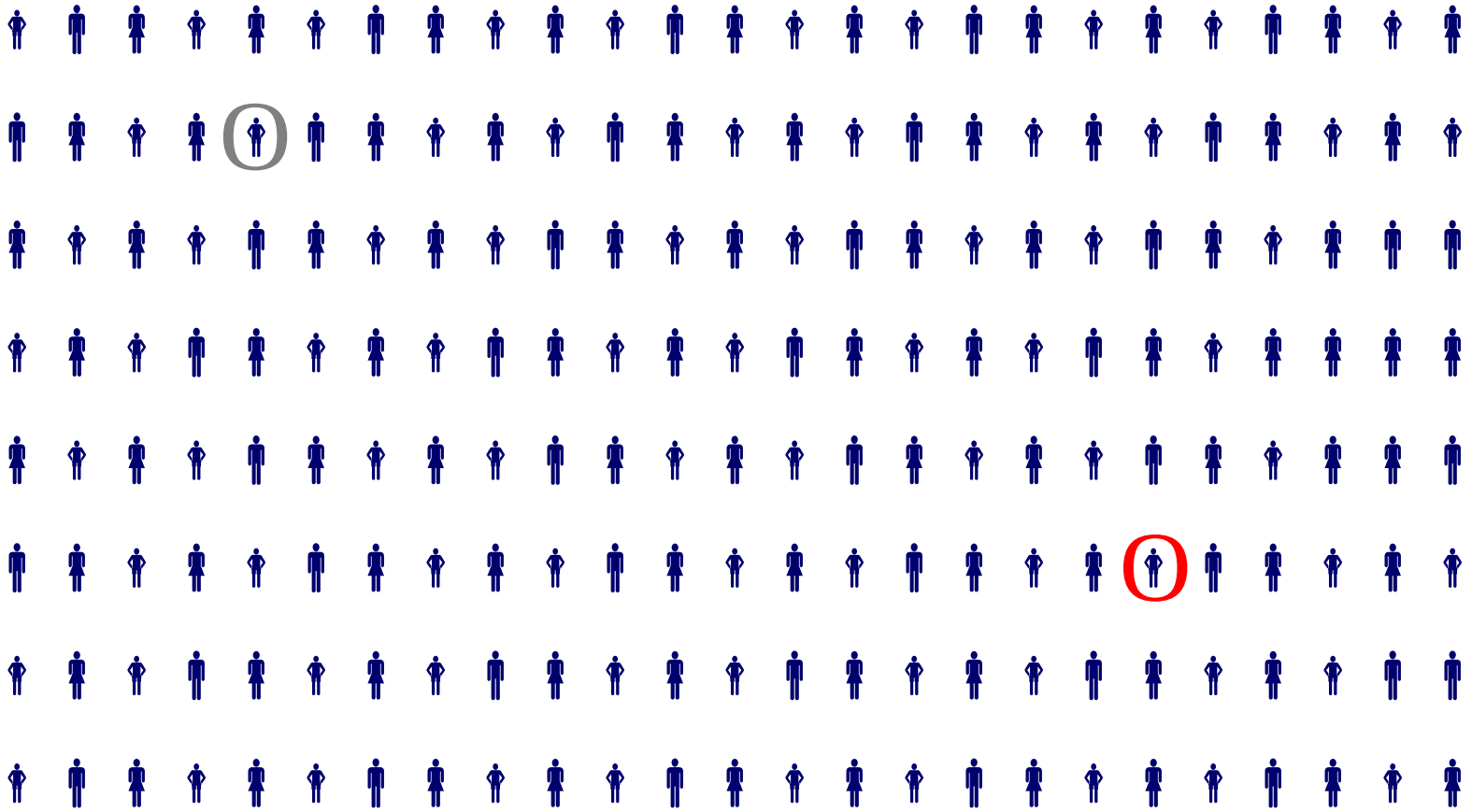

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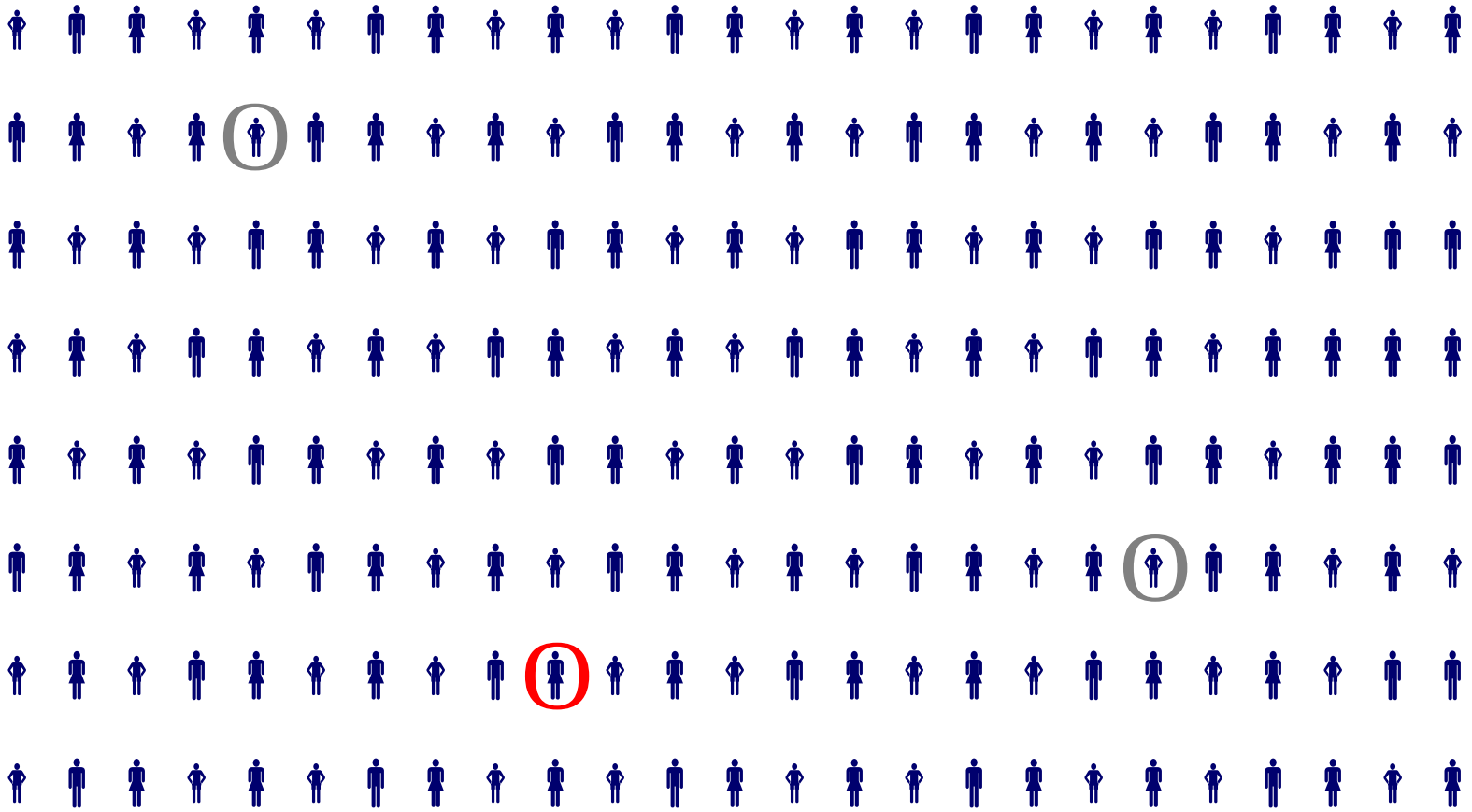

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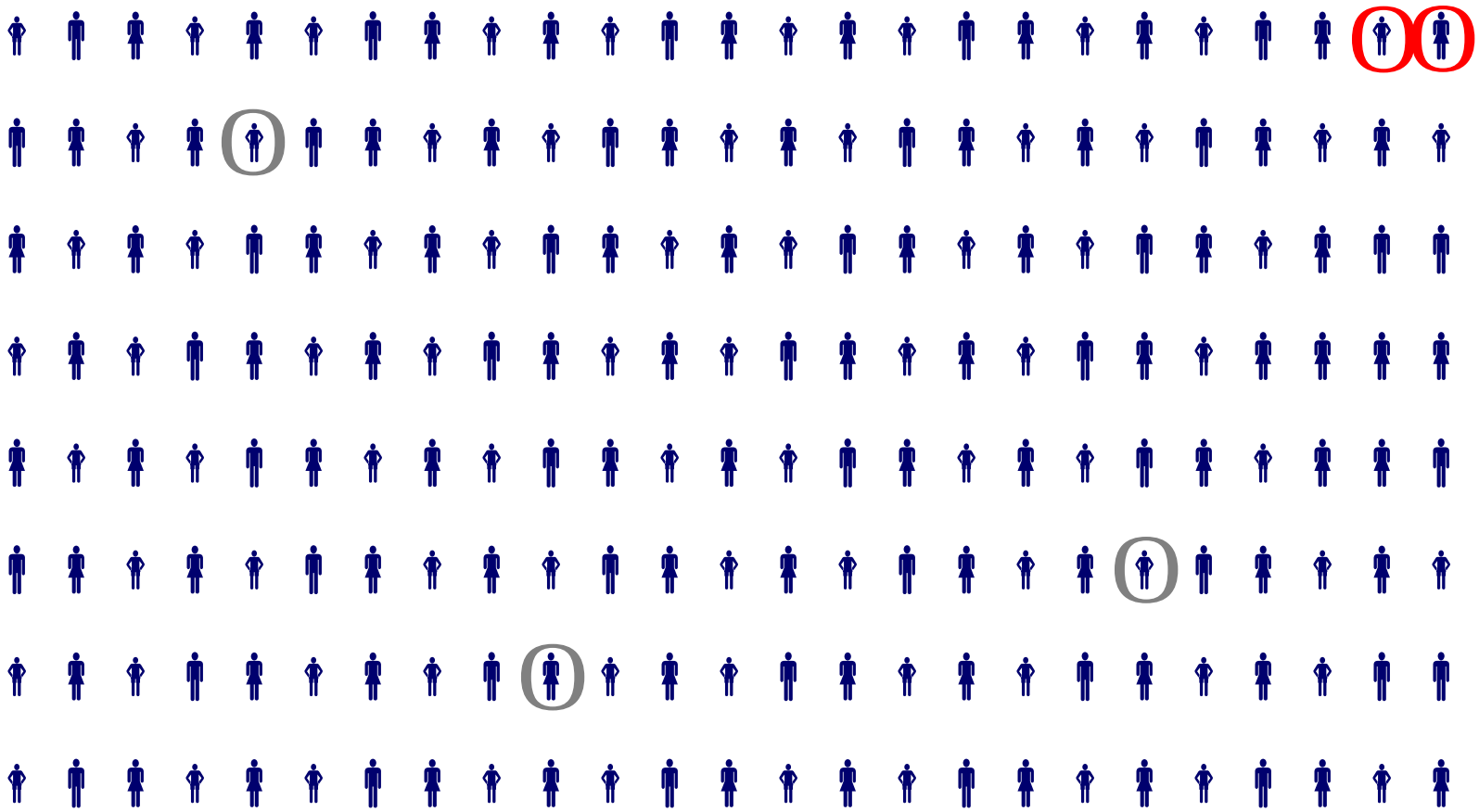

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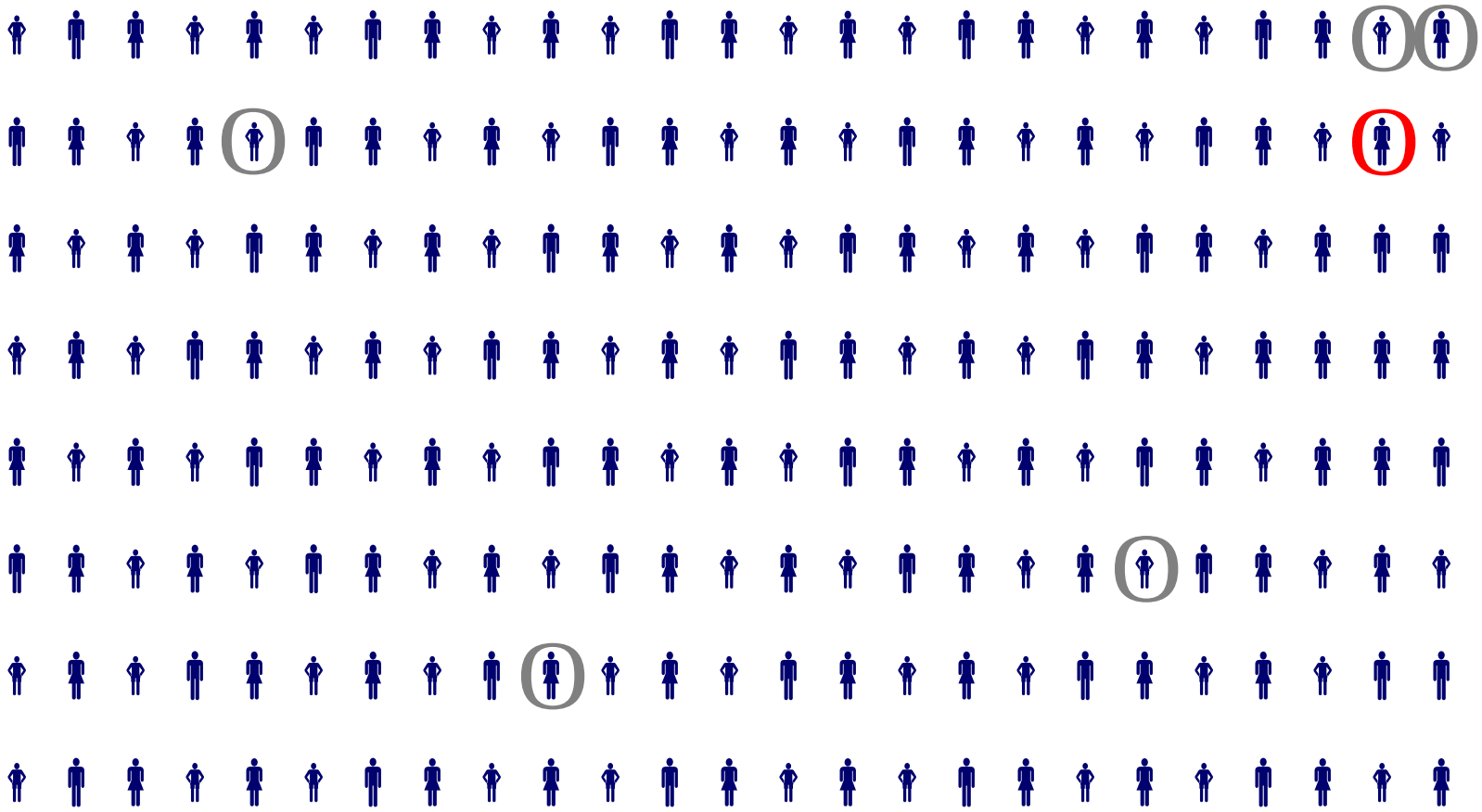
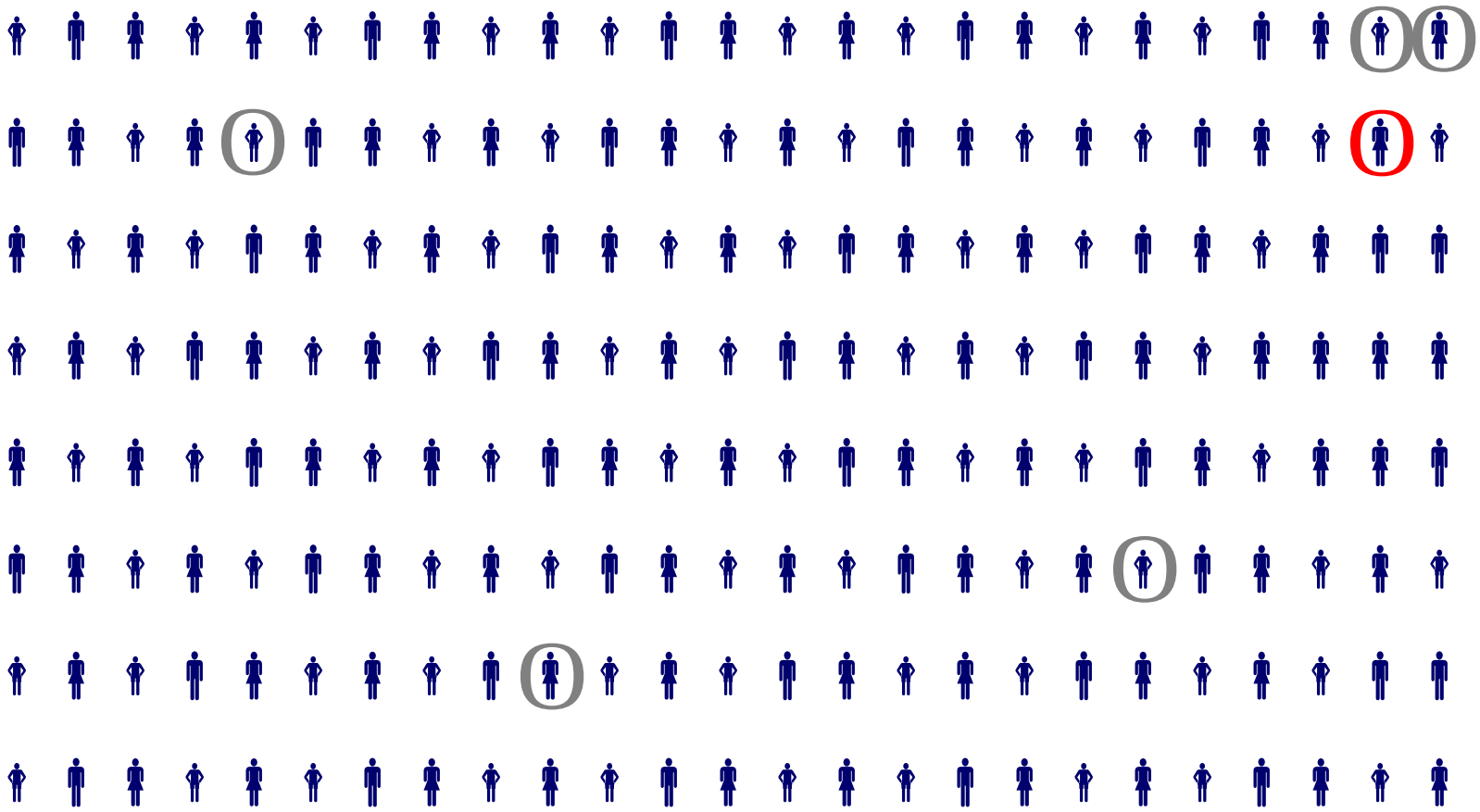
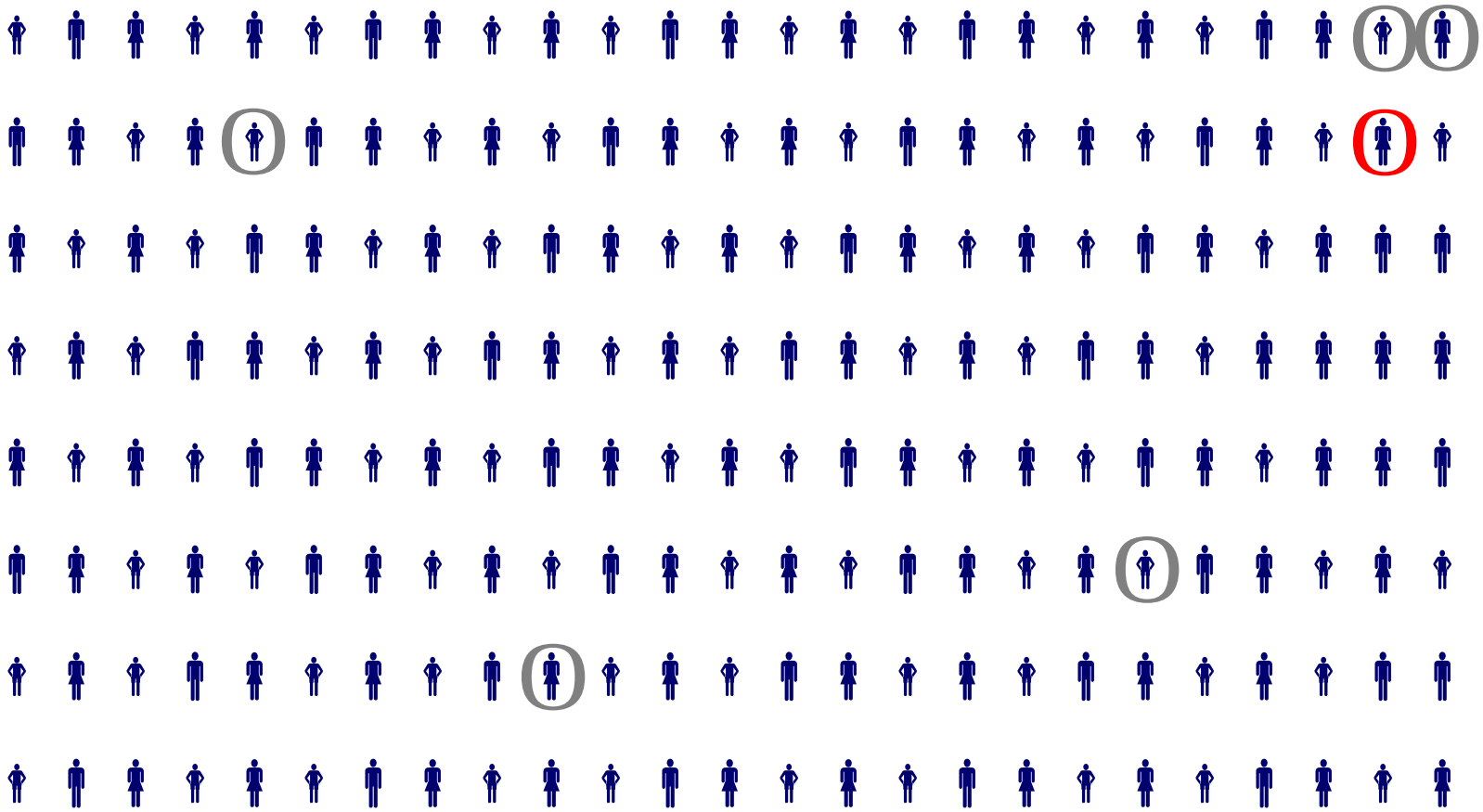


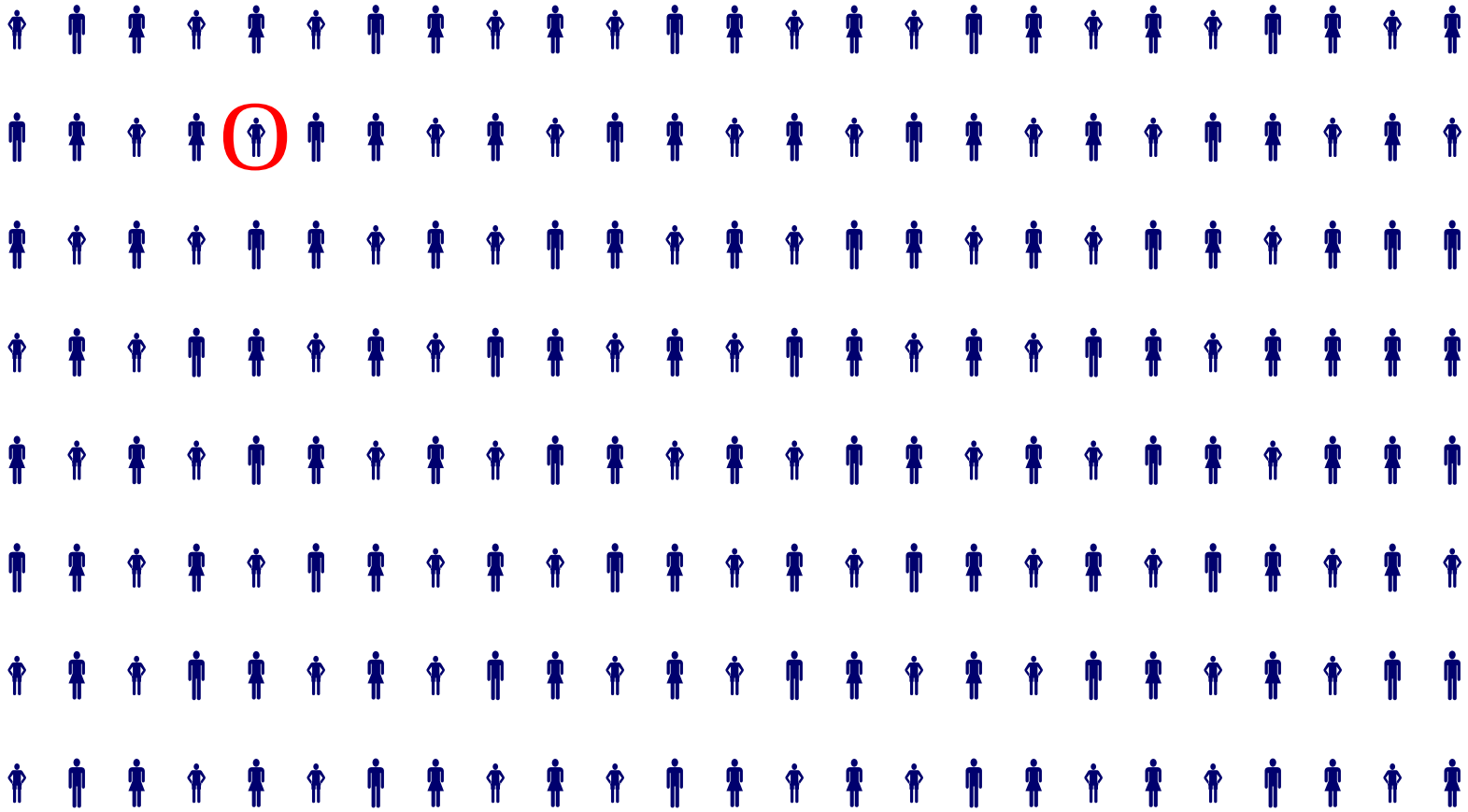
Rate of occurrence of new cases **over time**



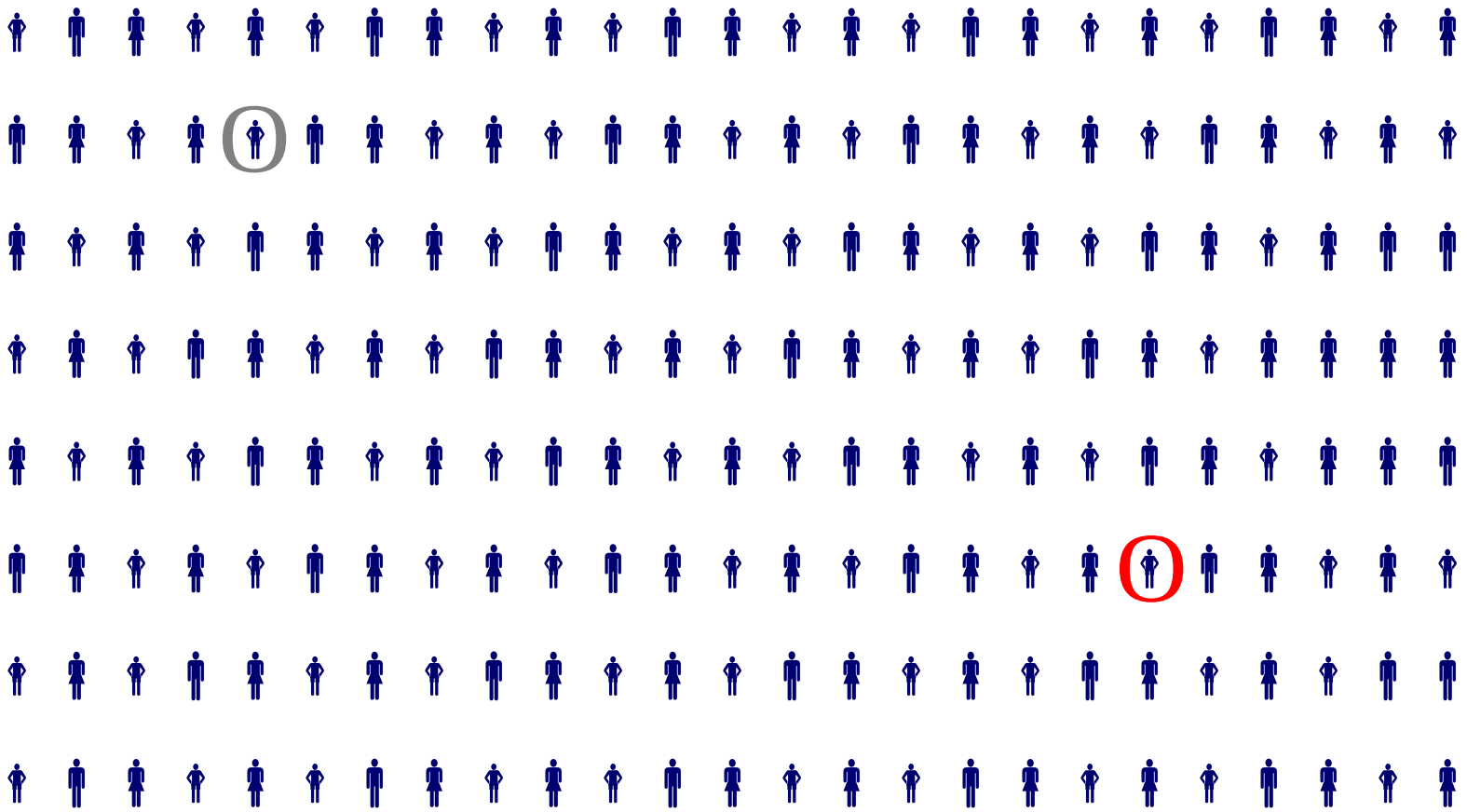
Rate of occurrence of **new cases per unit time** (e.g., 1 month)



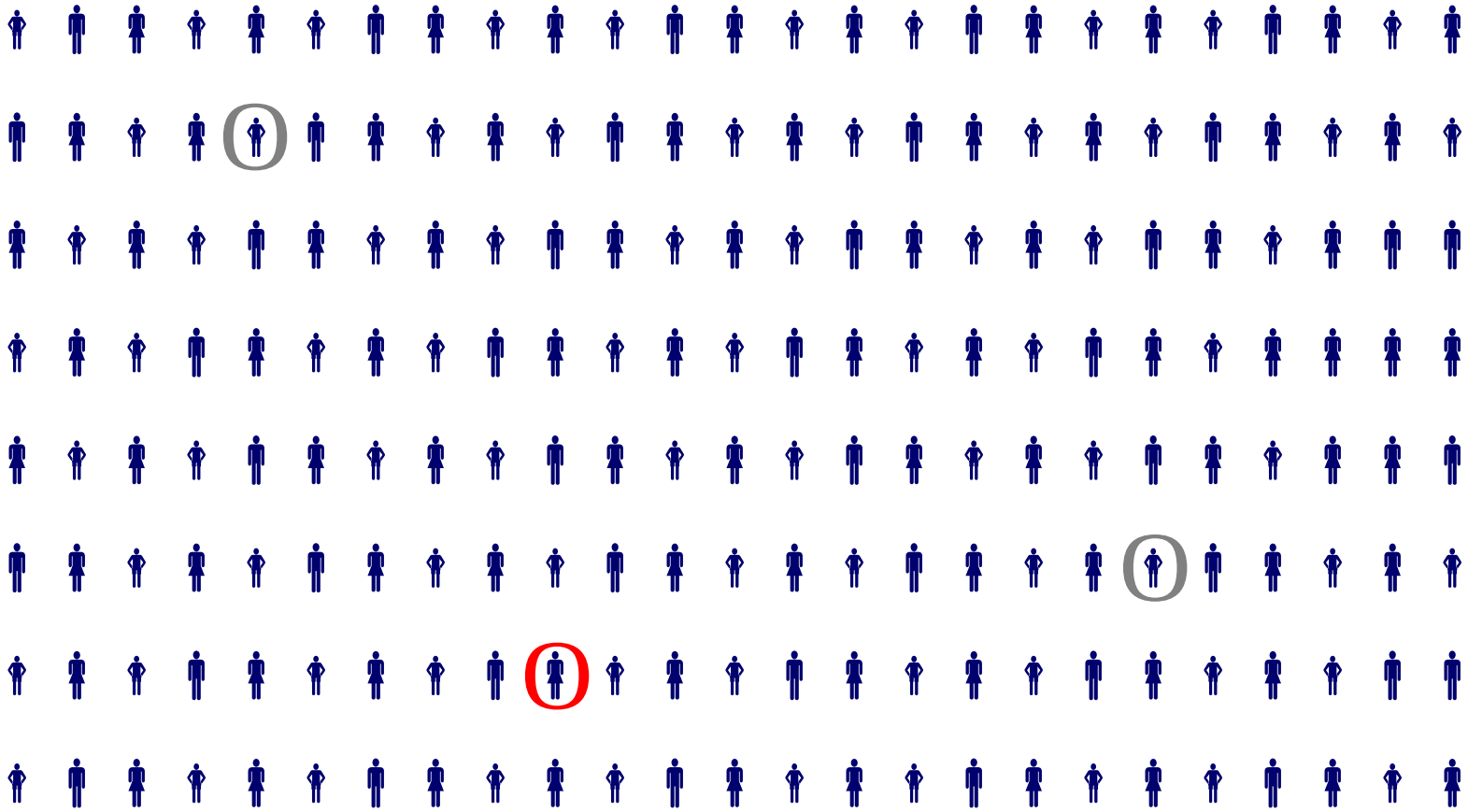
1 case in month 1



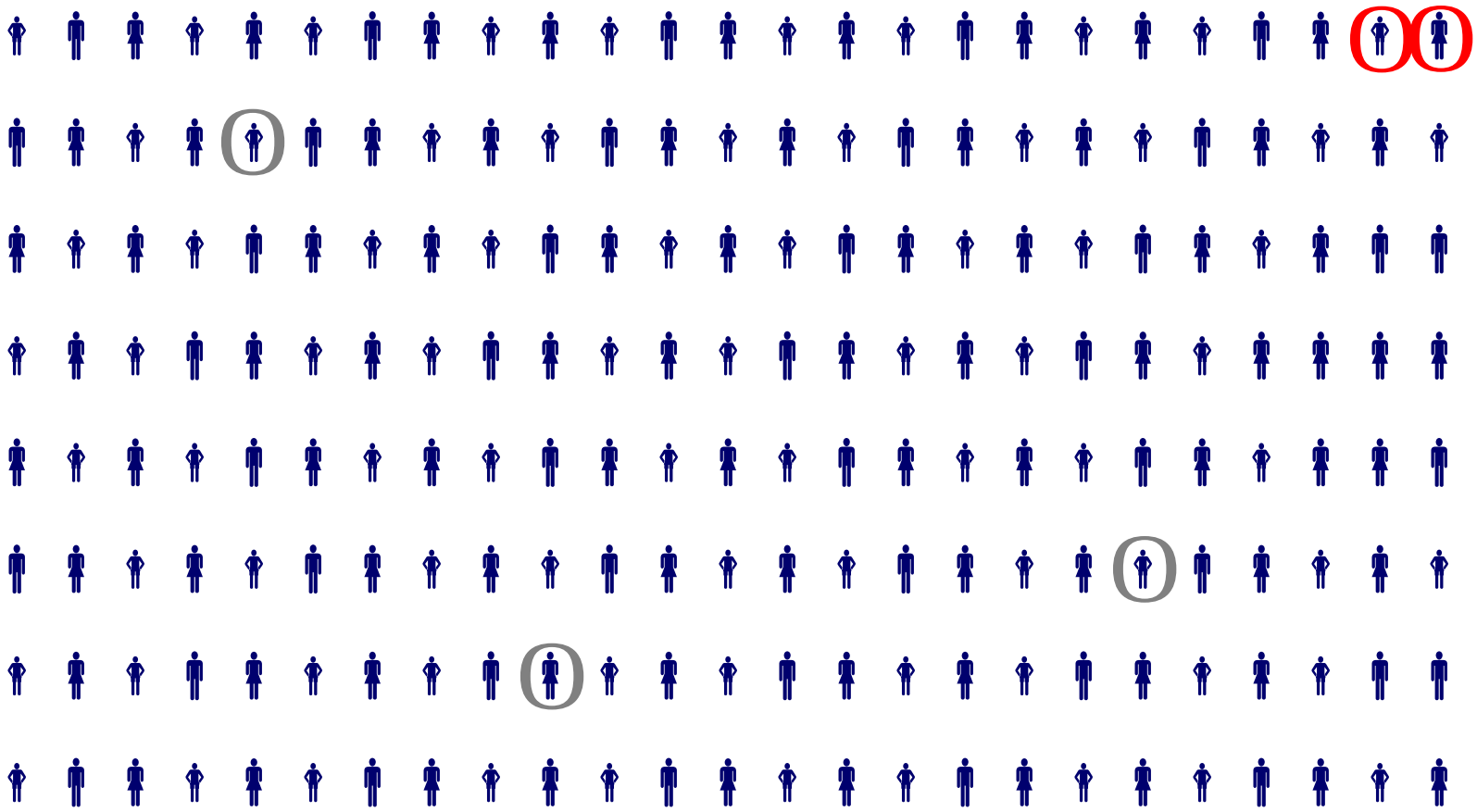
1 case in month 2



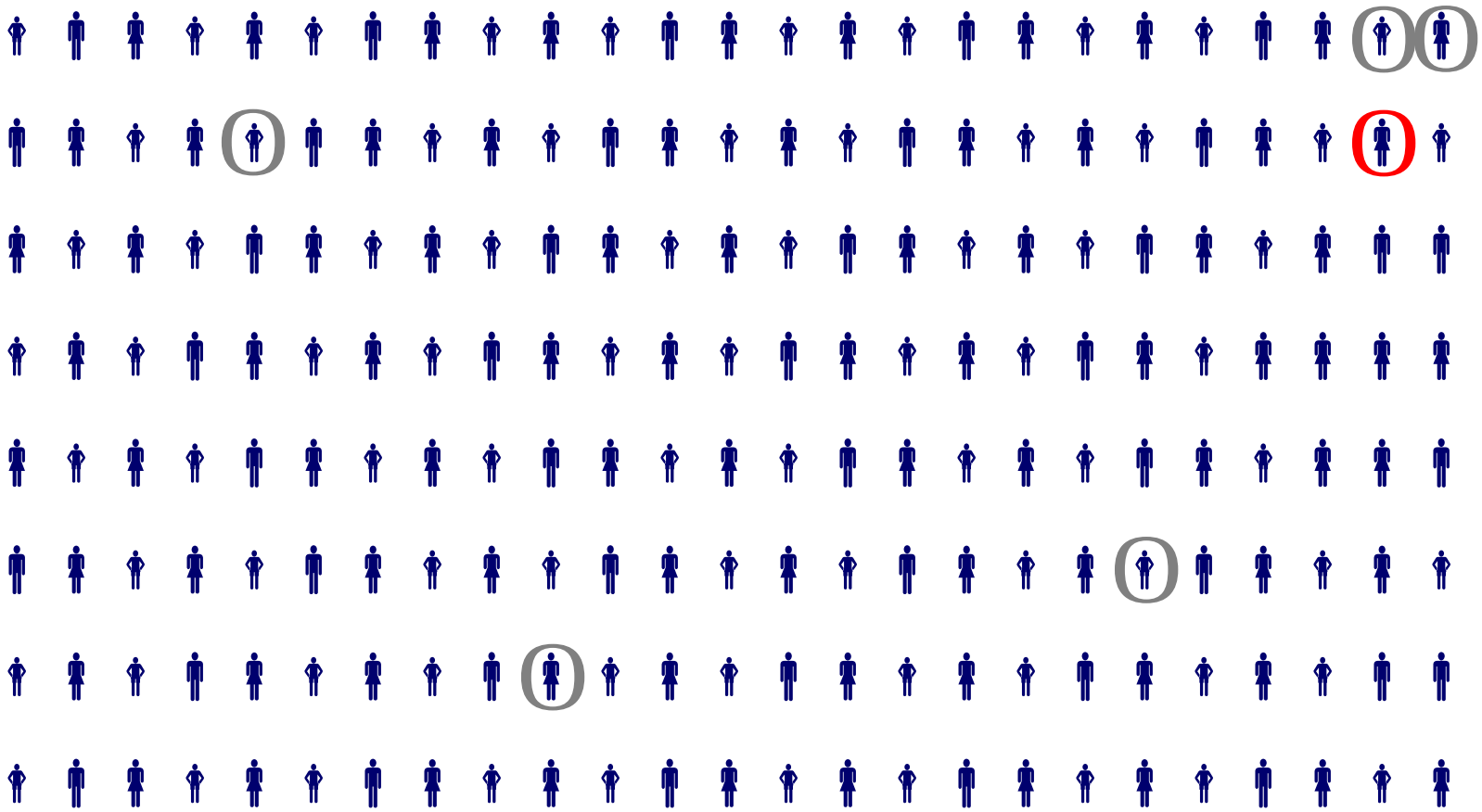
1 case in month 3



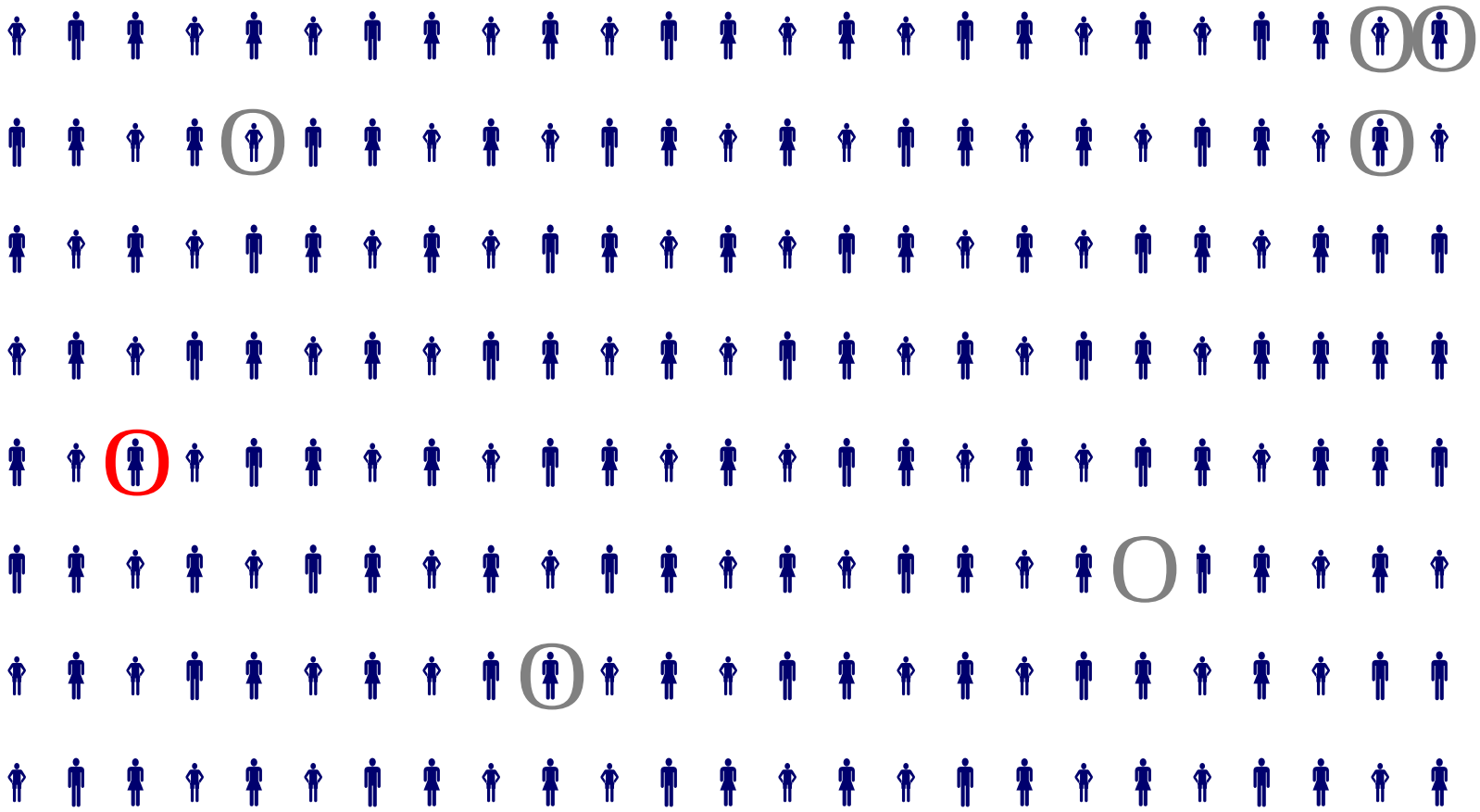
2 cases in month 4



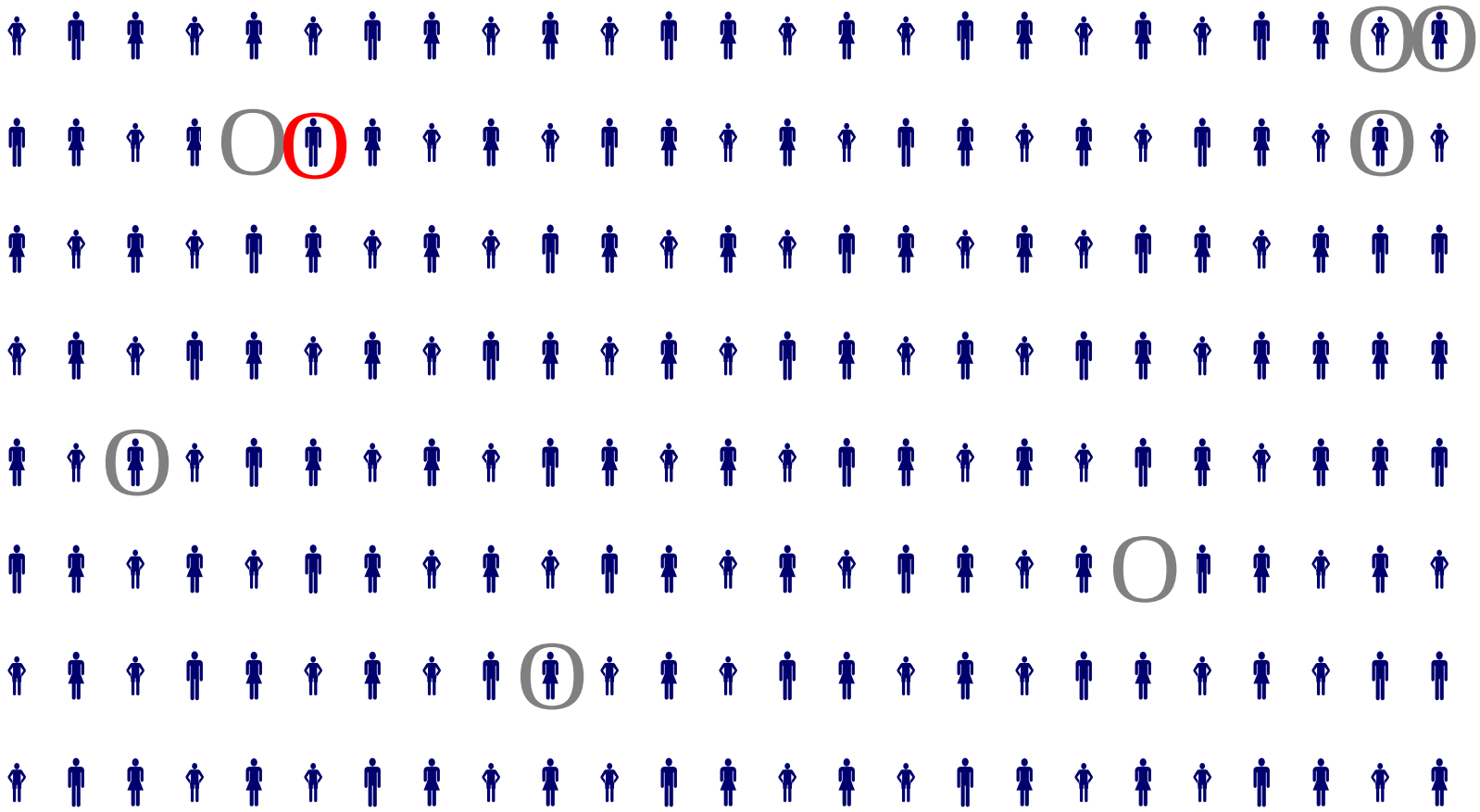
1 case in month 5



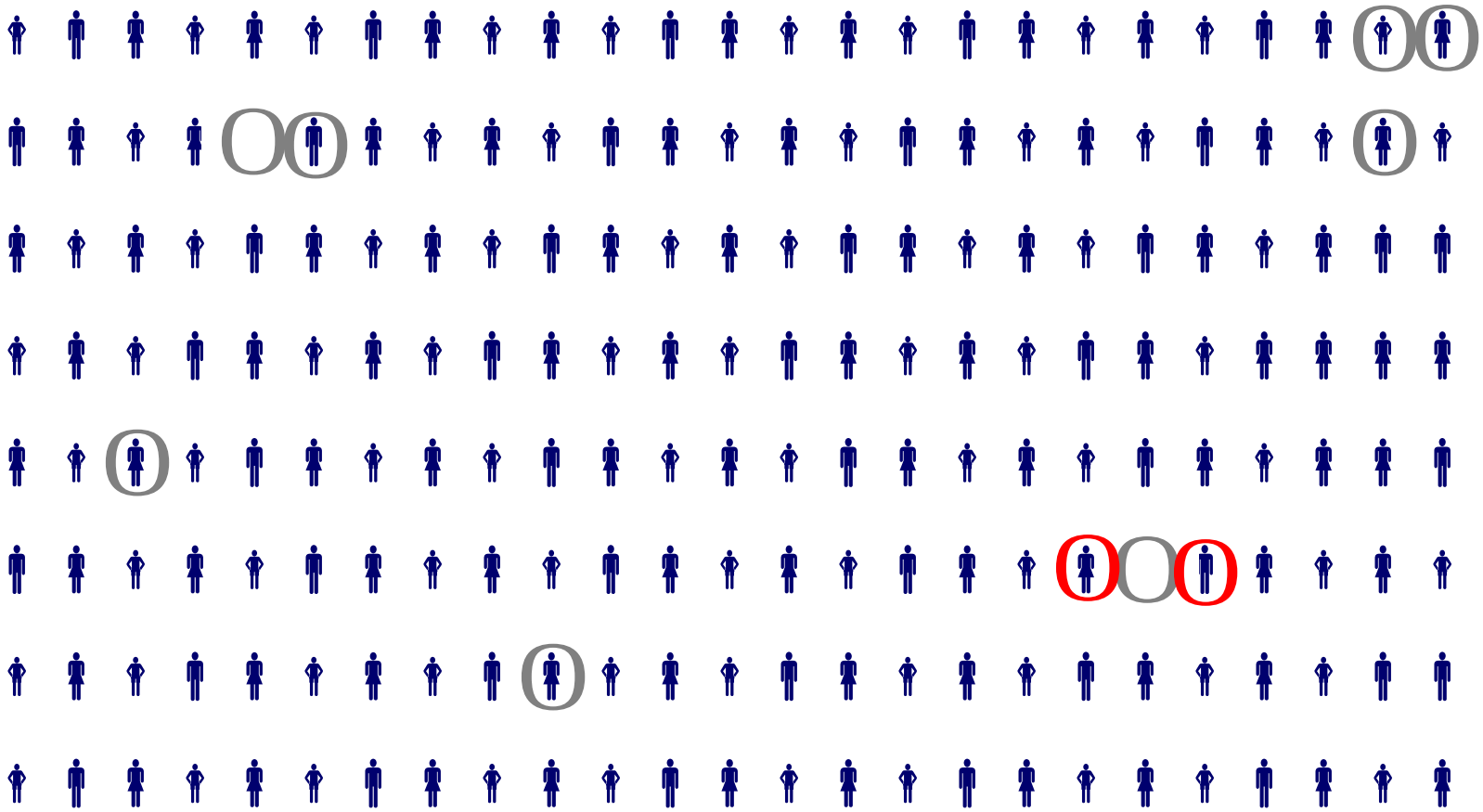
1 case in month 6



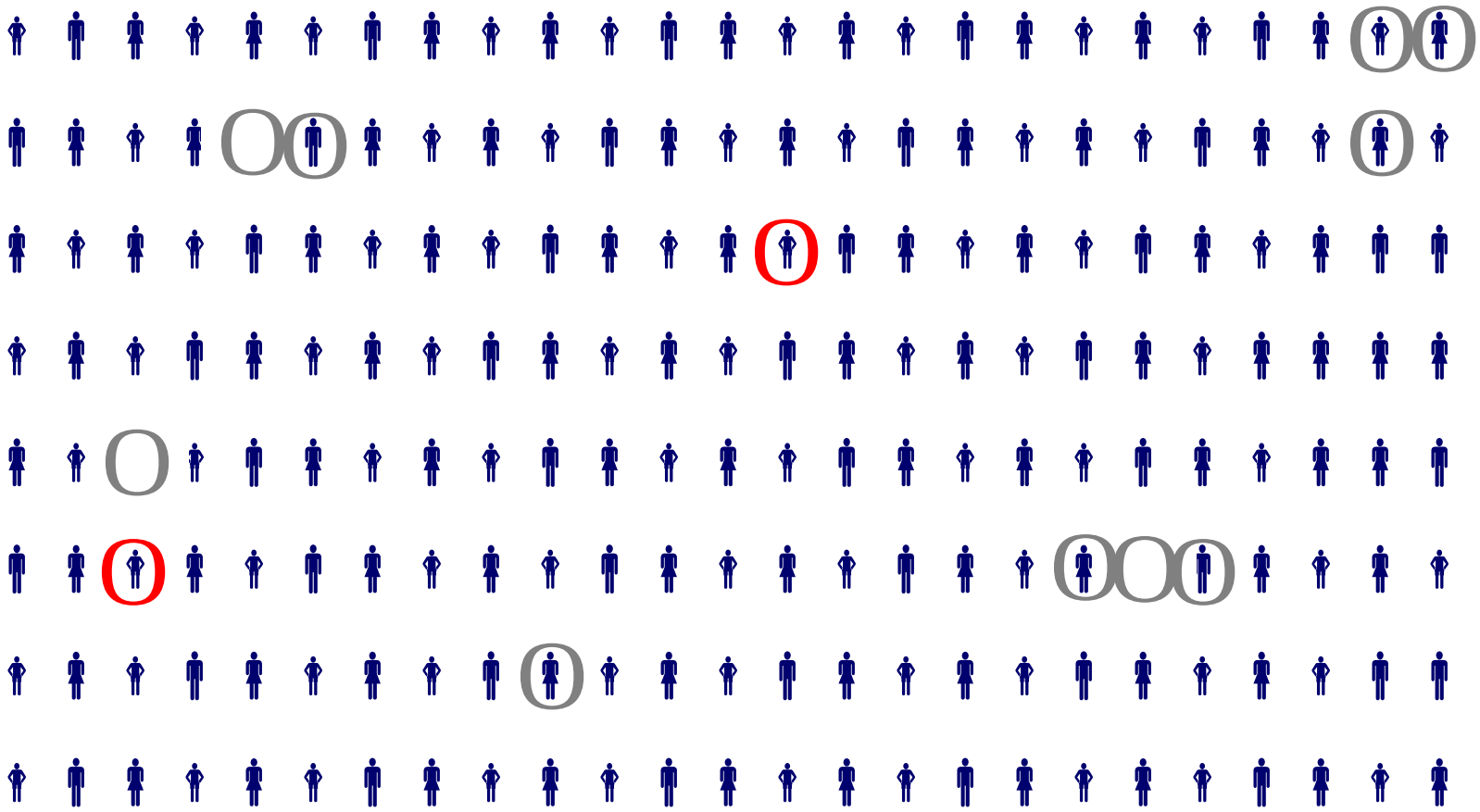
1 case in month 7



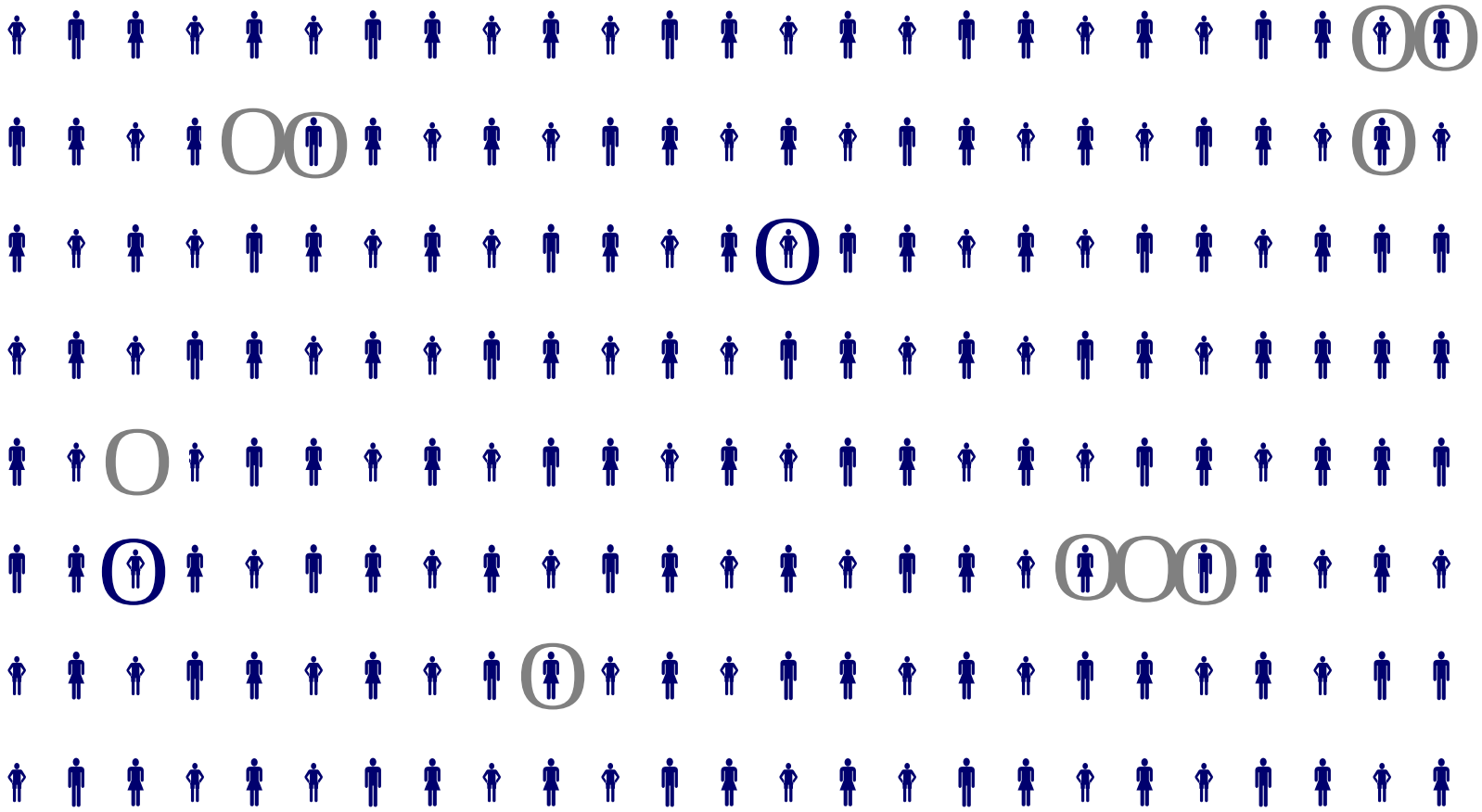
2 cases in month 8



2 cases in month 9



Rate of occurrence of new cases during 9 months: 1 case/month to 2 cases/month



Number of cases depends on length of interval

Divide by length of time interval, so can compare across intervals

$$\text{Rate of new cases} = \frac{\text{Number of new cases}}{\text{Time interval}}$$

= 12 cases / 9 months = 1.33 cases / month

Number of cases depends on population size

So, divide by population and time:

$$\text{Incidence rate} = \frac{\text{Number of new cases}}{\text{Population-time}}$$

How to estimate population-time?

Population at risk is the people available to be counted as a case. In this example that population declines as each case occurs.

So estimate population-time as . . .

Population-time =

1. the sum of the size of the population at risk during each small time segment

or

2. the average size of the population at risk multiplied by the length of the time interval

Estimating population-time - method 1

Total population-time over 9 months =

200 + 199 + 198 + 197 + 195 + 194 + 193 + 192 + 190

= 1,758 person-months

= 146.5 person-years

However, cases are not at risk for a full month.

Estimating population-time - method 1 - better

Total population-time over 9 months =

199.5 + 198.5 + 197.5 + 196 + 194.5 + 193.5 + 192.5 + 191 + 189

= 1,752 person-months

= 146 person-years

assuming that cases develop, on average, in the middle of the month

Estimating population-time - method 2

Average size of the population at risk during the 9 months = 195.3 (1,758 / 9) or approximately: (200 + 188) /2 = 194

Population-time = 195.3 x 9 months or (approximately) 194 x 9 months

= 1,746 person-months

= 145.5 person-years

Equivalent to - method 2

Take initial size of population at risk and reduce it for time the people were not at risk due to acquiring the disease:

200 - 12/2 = 194 (approximately)

Population-time = 194 x 9 months

= 1,746 person-months

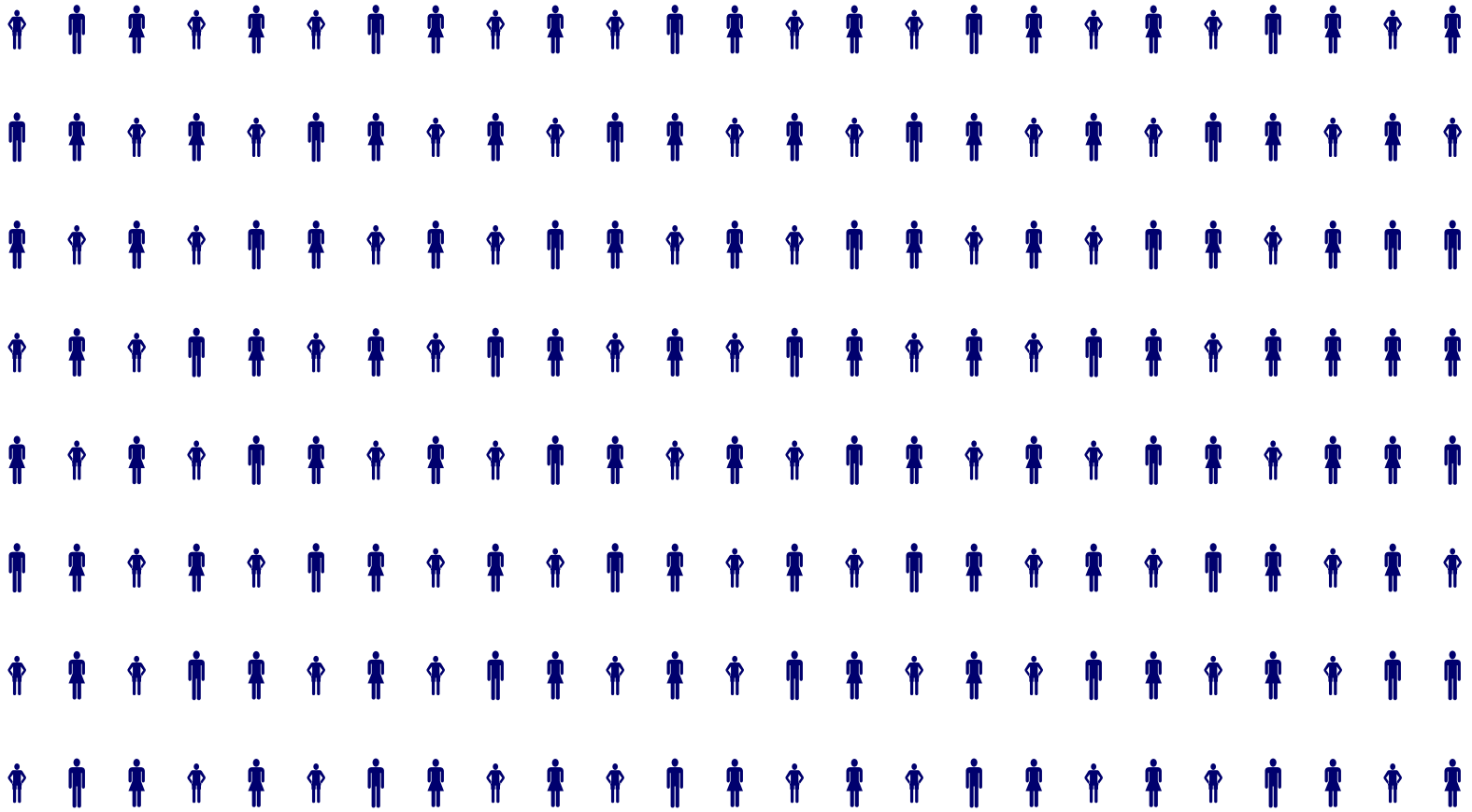
= 145.5 person-years

Incidence rate ("incidence density")

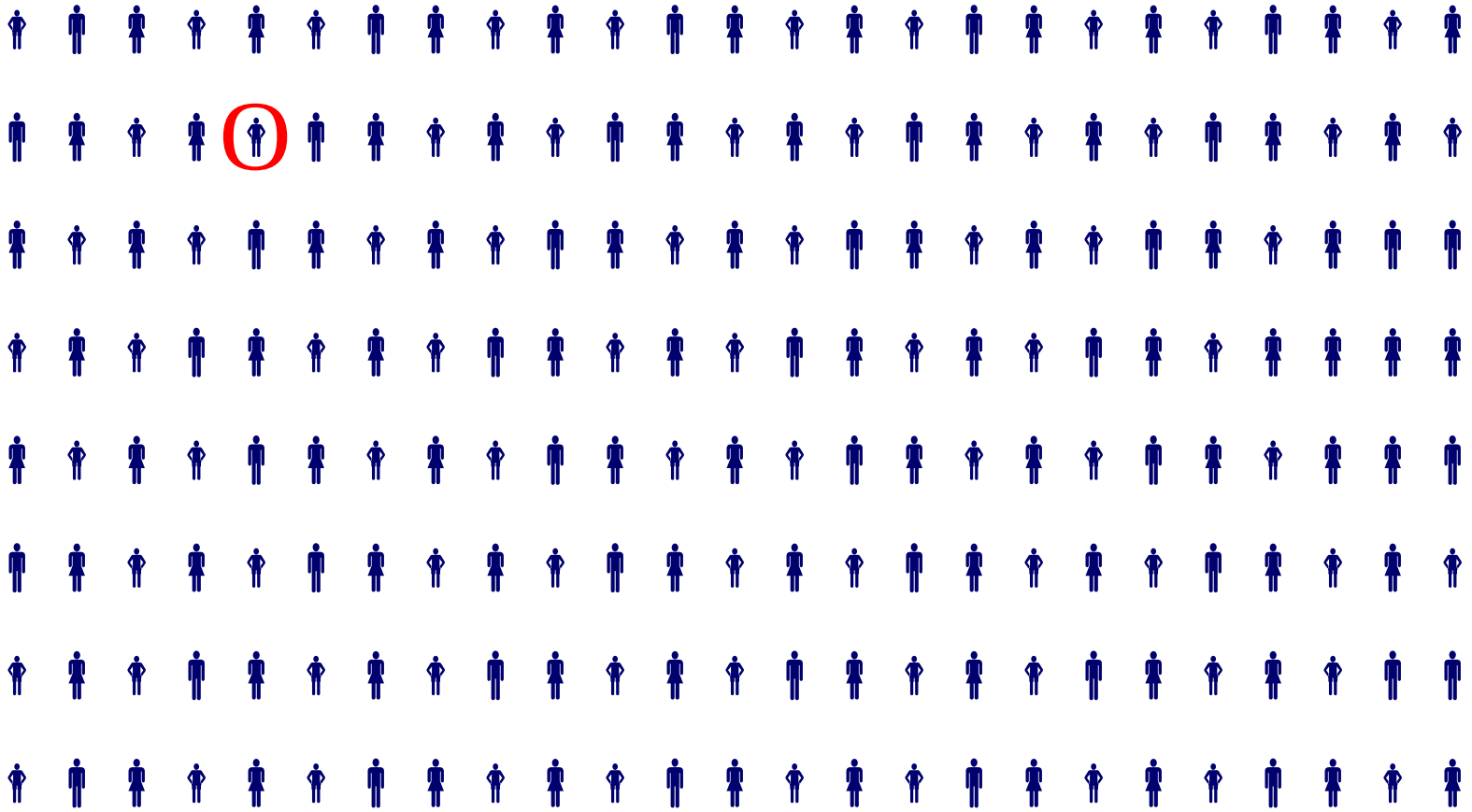
$$\frac{\text{Number of new cases}}{\text{Avg population at risk} \times \text{Time interval}}$$

$$= \frac{\text{Number of new cases}}{\text{Population-time}}$$

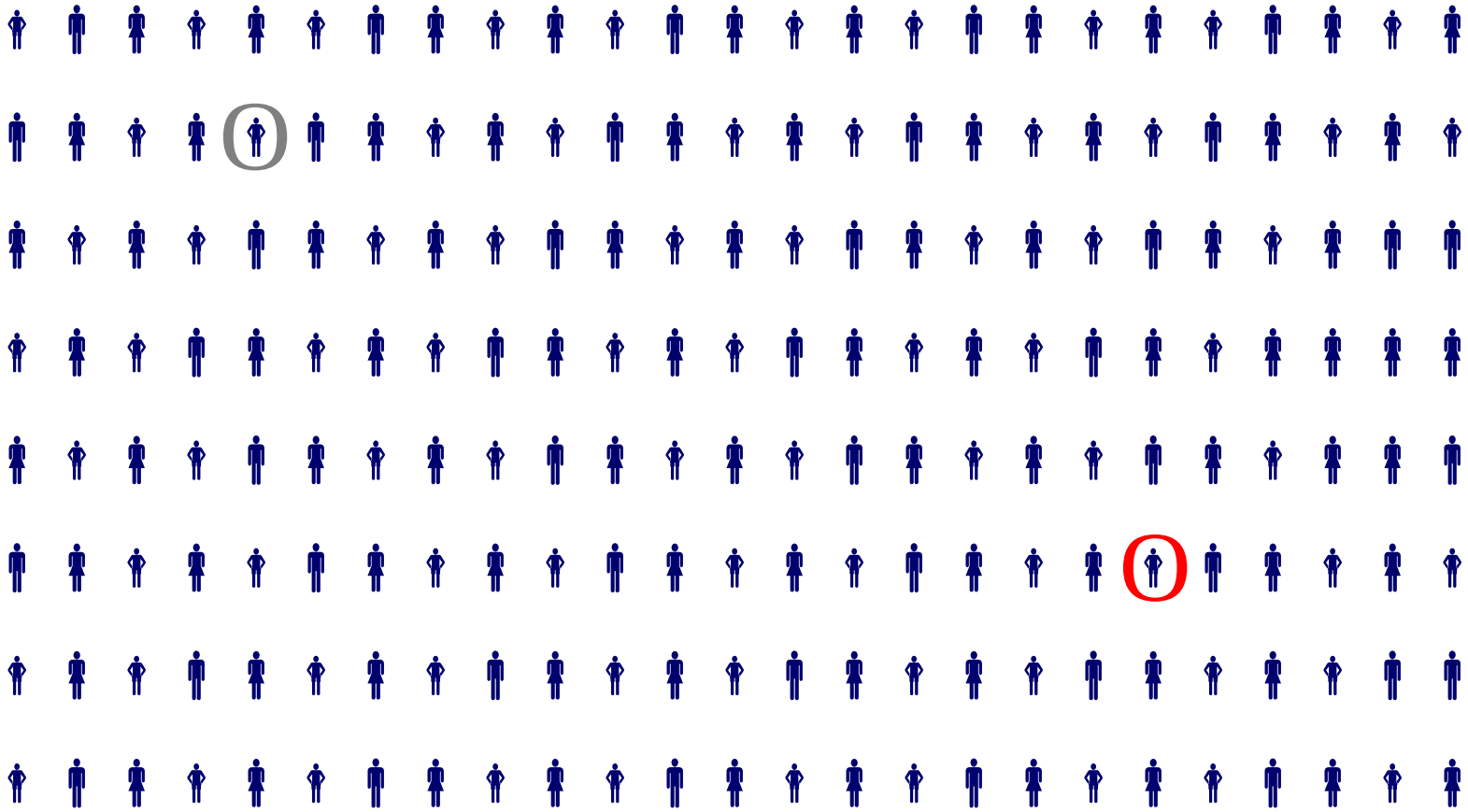
What proportion of the population is affected after 5 months?



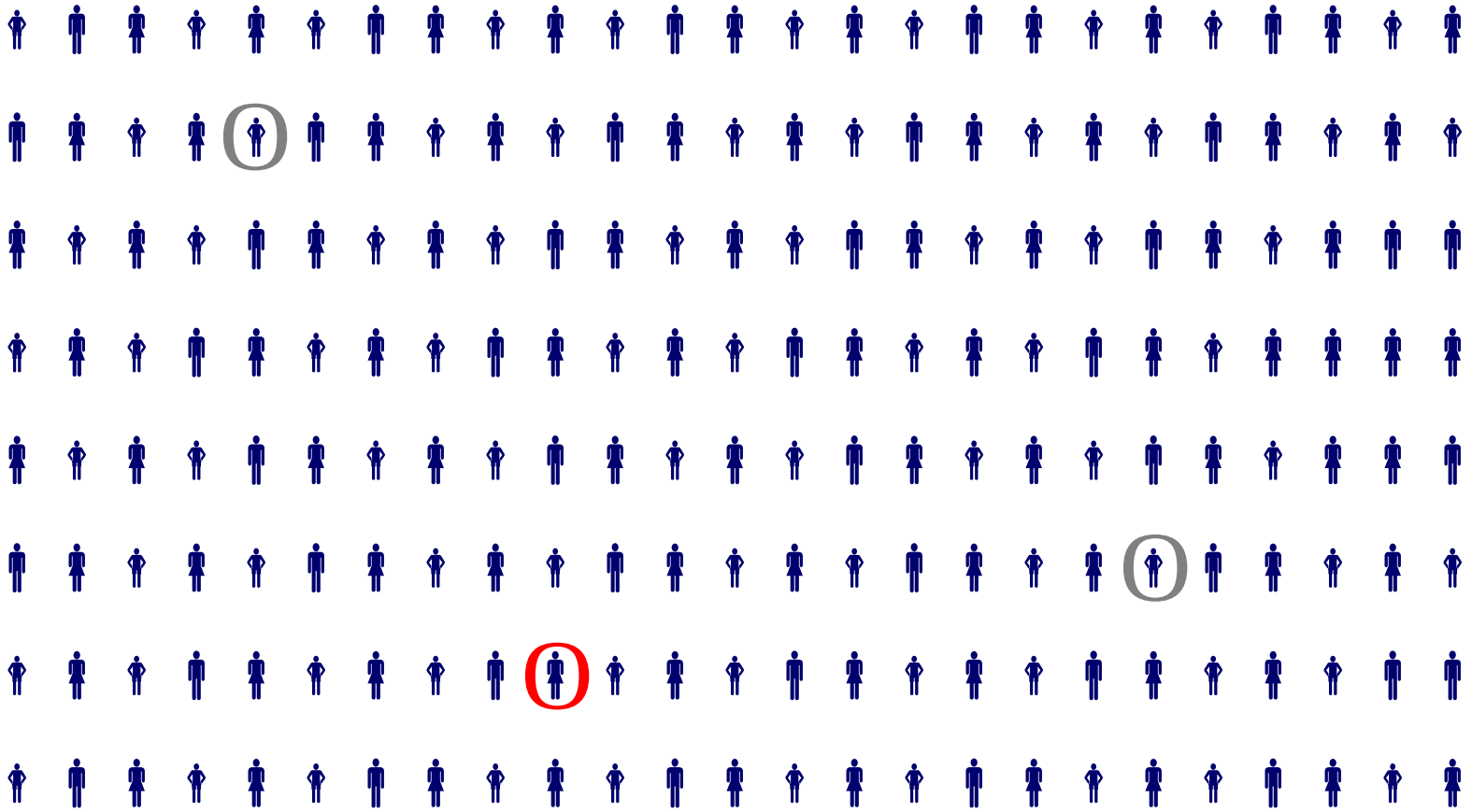
What proportion of the population is affected after 5 months? (1/200)



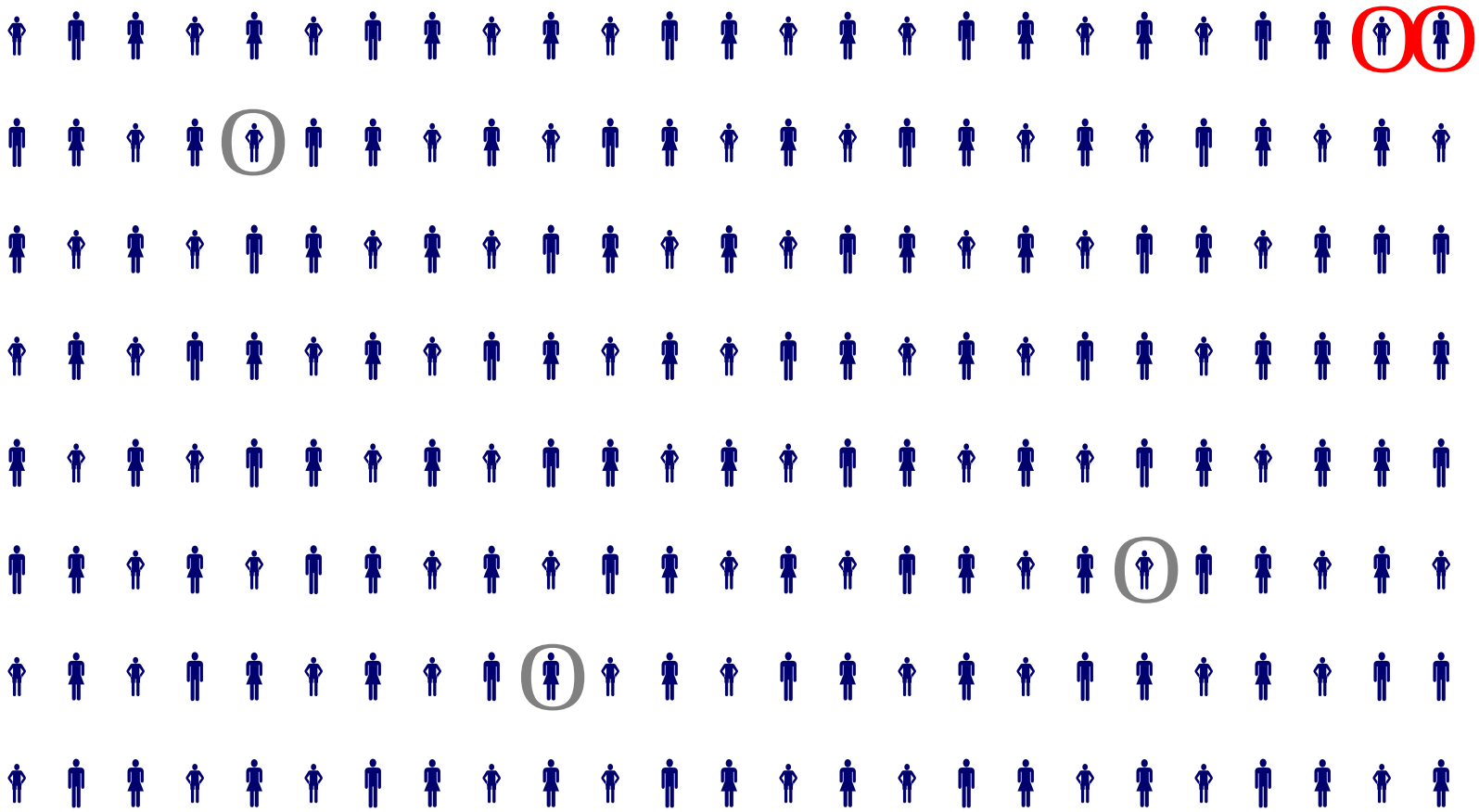
What proportion of the population is affected after 5 months? (2/200)



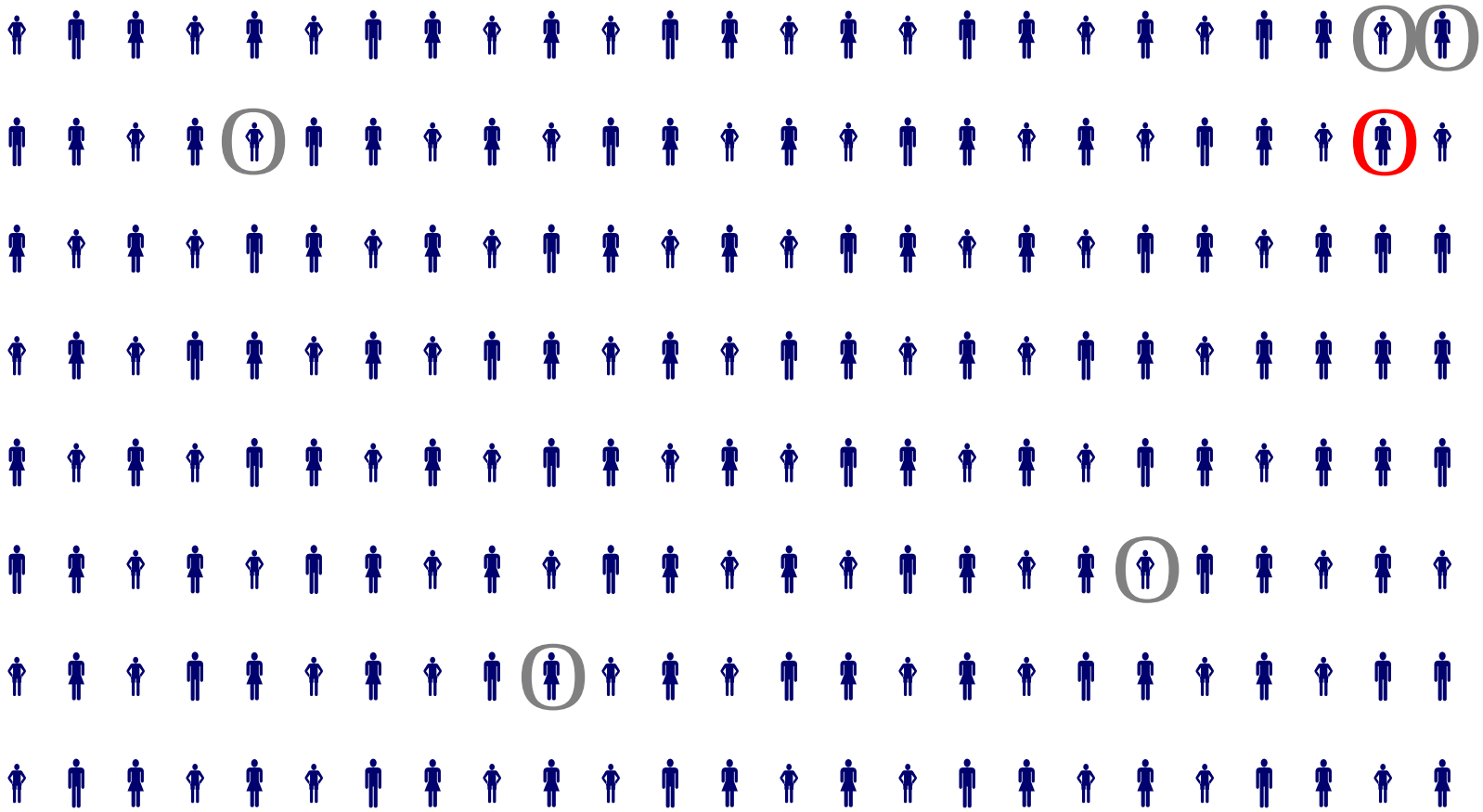
What proportion of the population is affected after 5 months? (3/200)



What proportion of the population is affected after 5 months? (5/200)



6 / 200 = 0.03 = 3% = 30 / 1,000 in 5 months



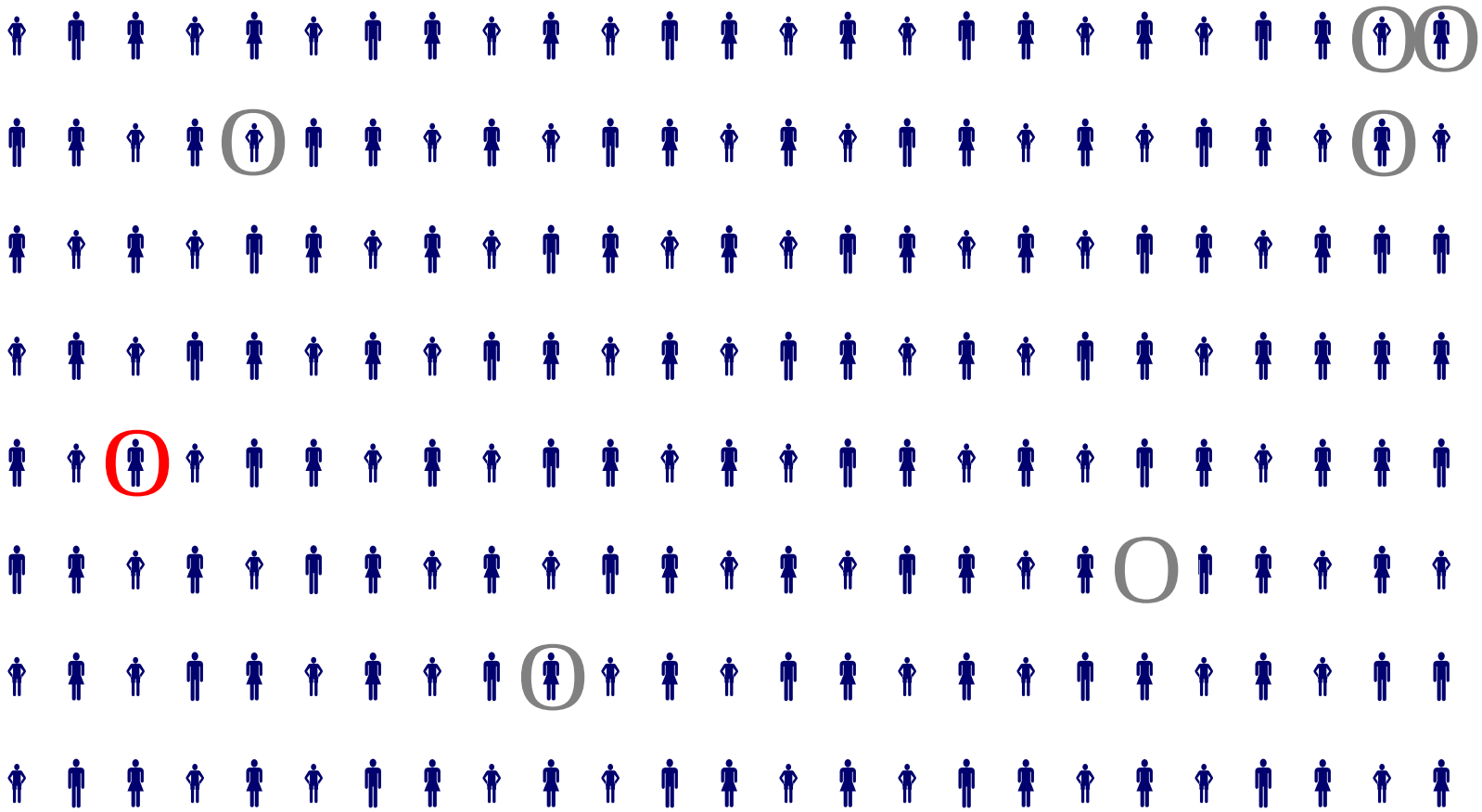
Incidence proportion (“cumulative incidence”)

$$\text{5-month CI} = \frac{\text{Number of new cases}}{\text{Population at risk}}$$

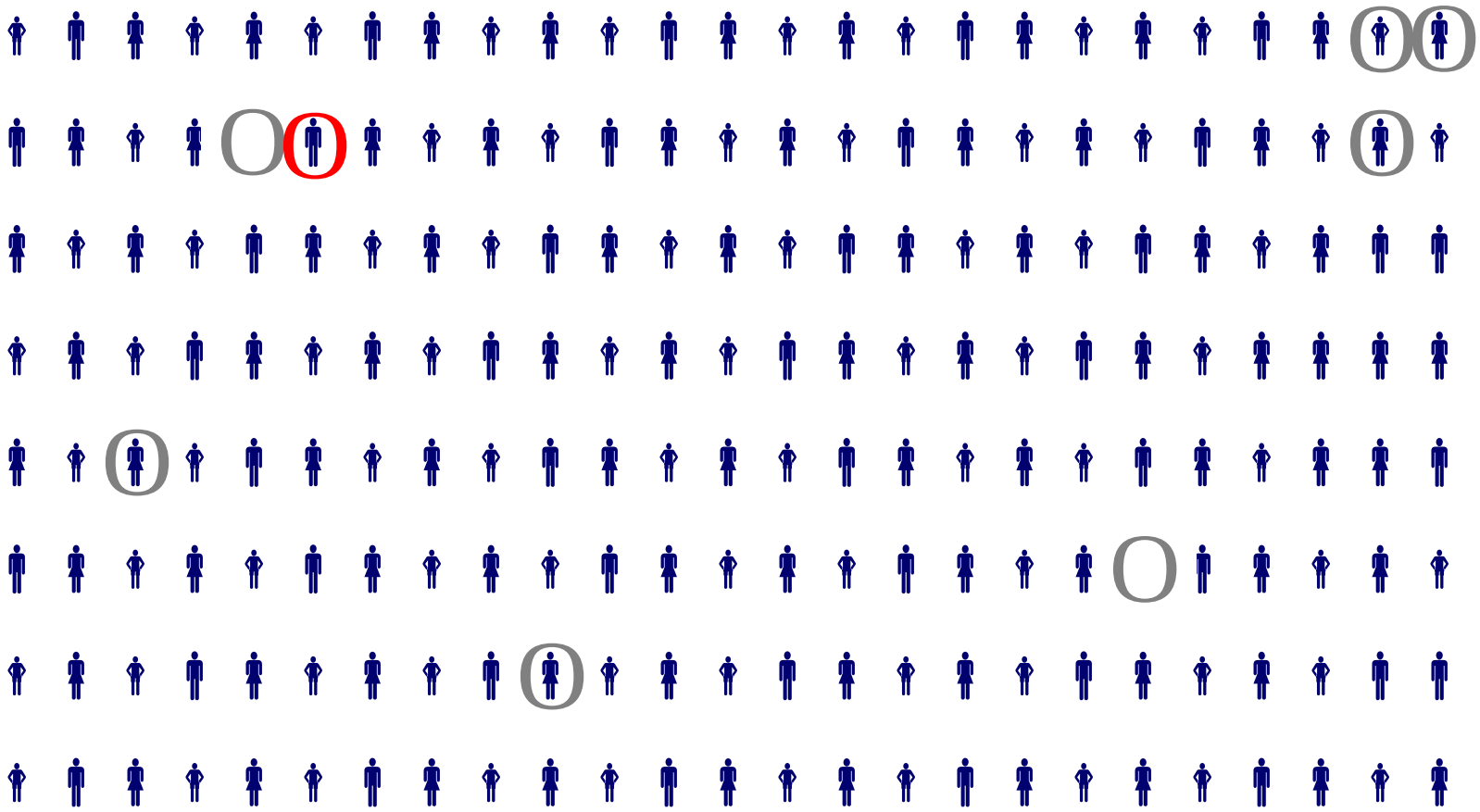
Prevalence – another important proportion

$$\text{Prevalence} = \frac{\text{Number of existing (and new) cases}}{\text{Population at risk}}$$

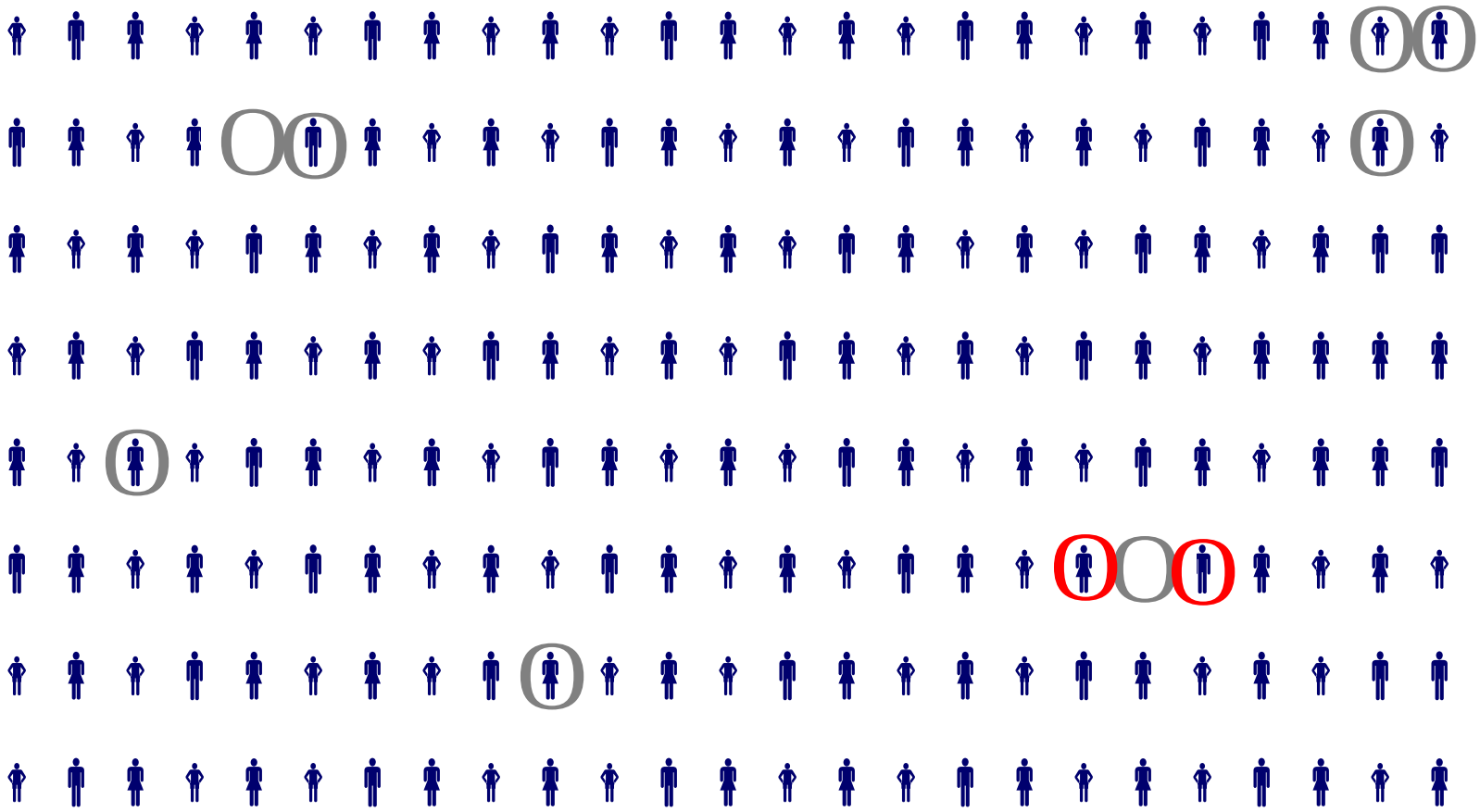
1 new case, 1 death



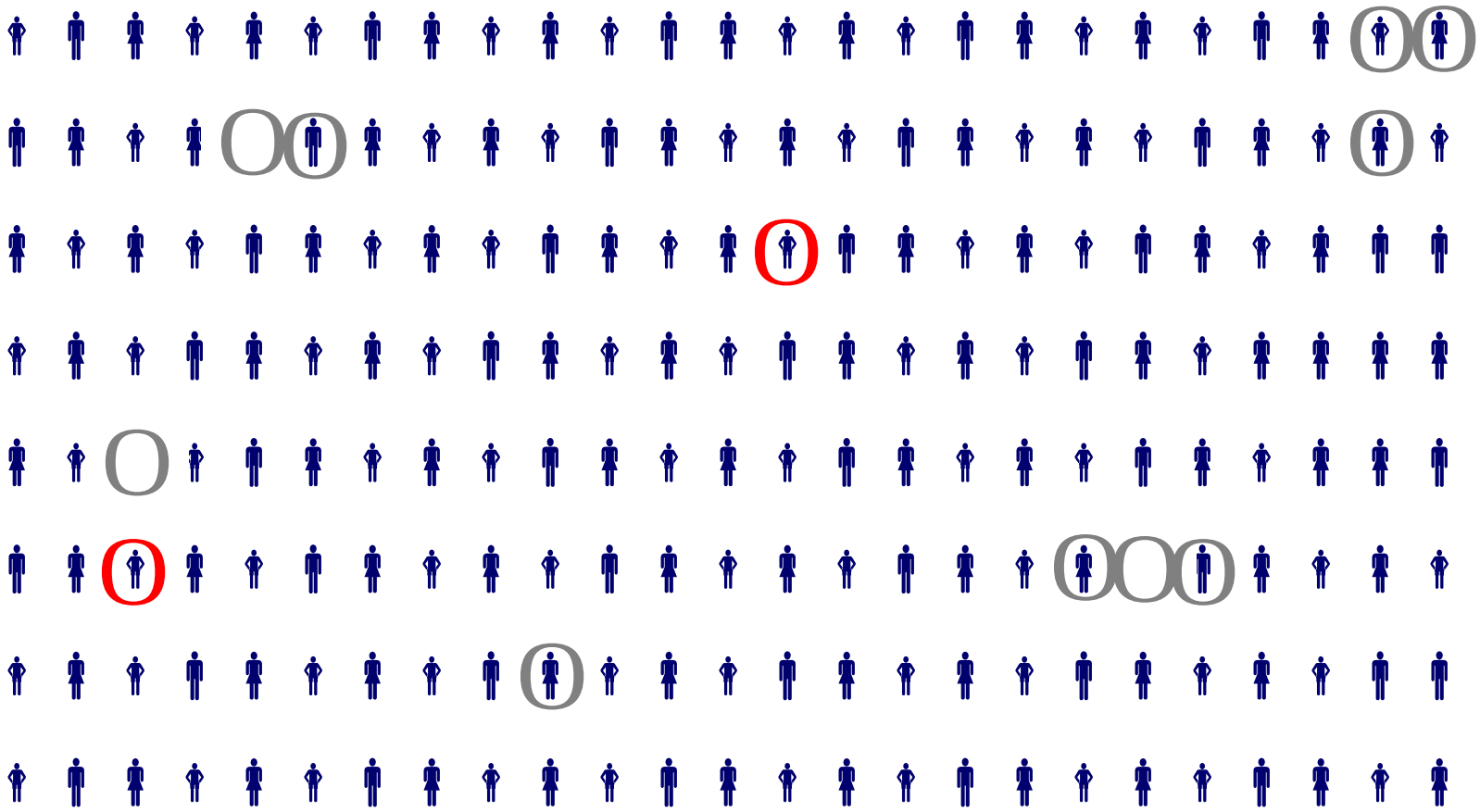
1 new case, 1 new death



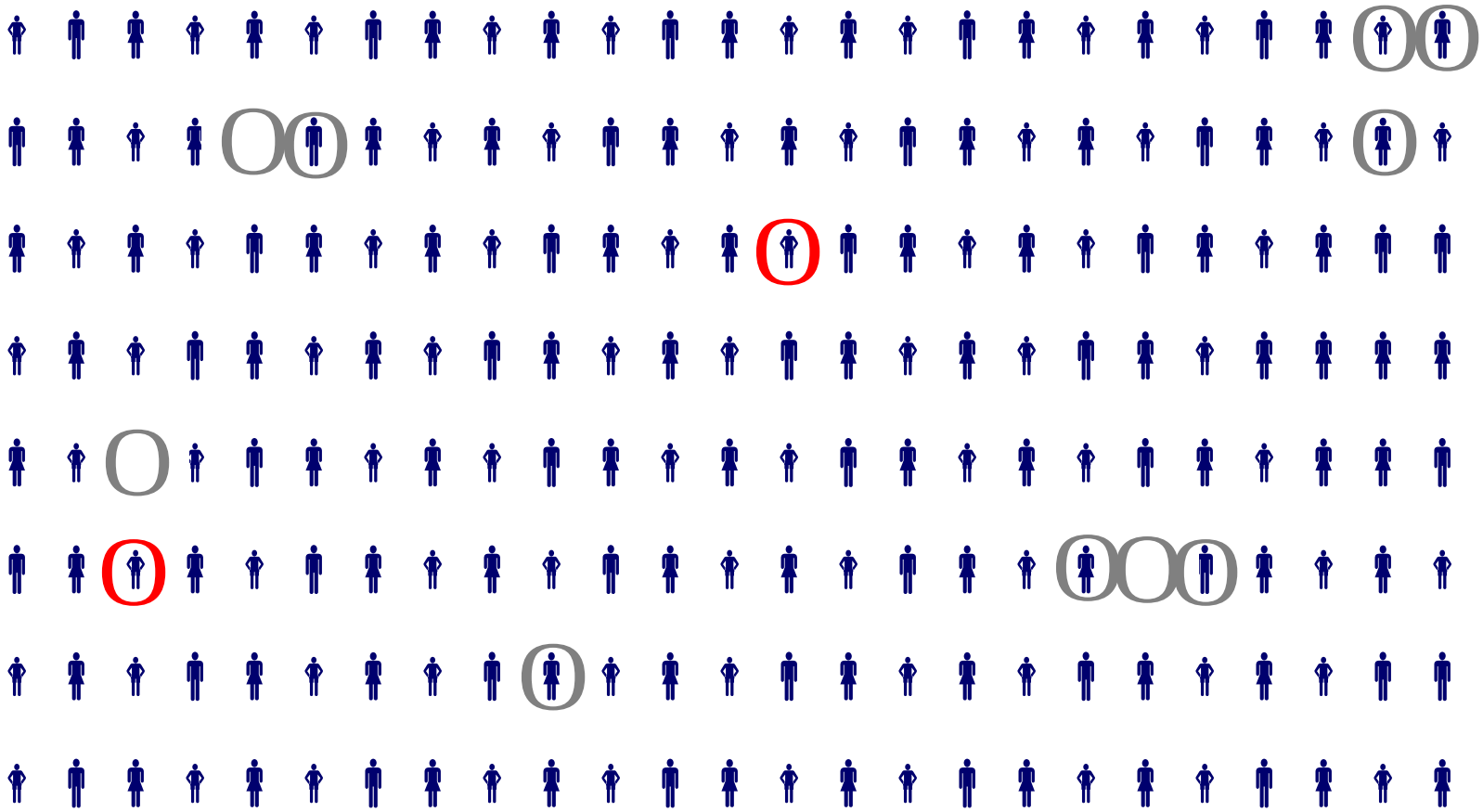
2 new cases, no deaths



2 new cases, 1 new death



What is the prevalence? (9 / 197)



Fine points . . .

- Who is “at risk”?
  - Only women? Only men?
  - Only women who have not had a hysterectomy?
  - Genetically susceptible?

More fine points . . .

- How do we measure time?
  - Are 10 people followed for 10 years the same as 100 people followed for 1 year?

Fine points . . .

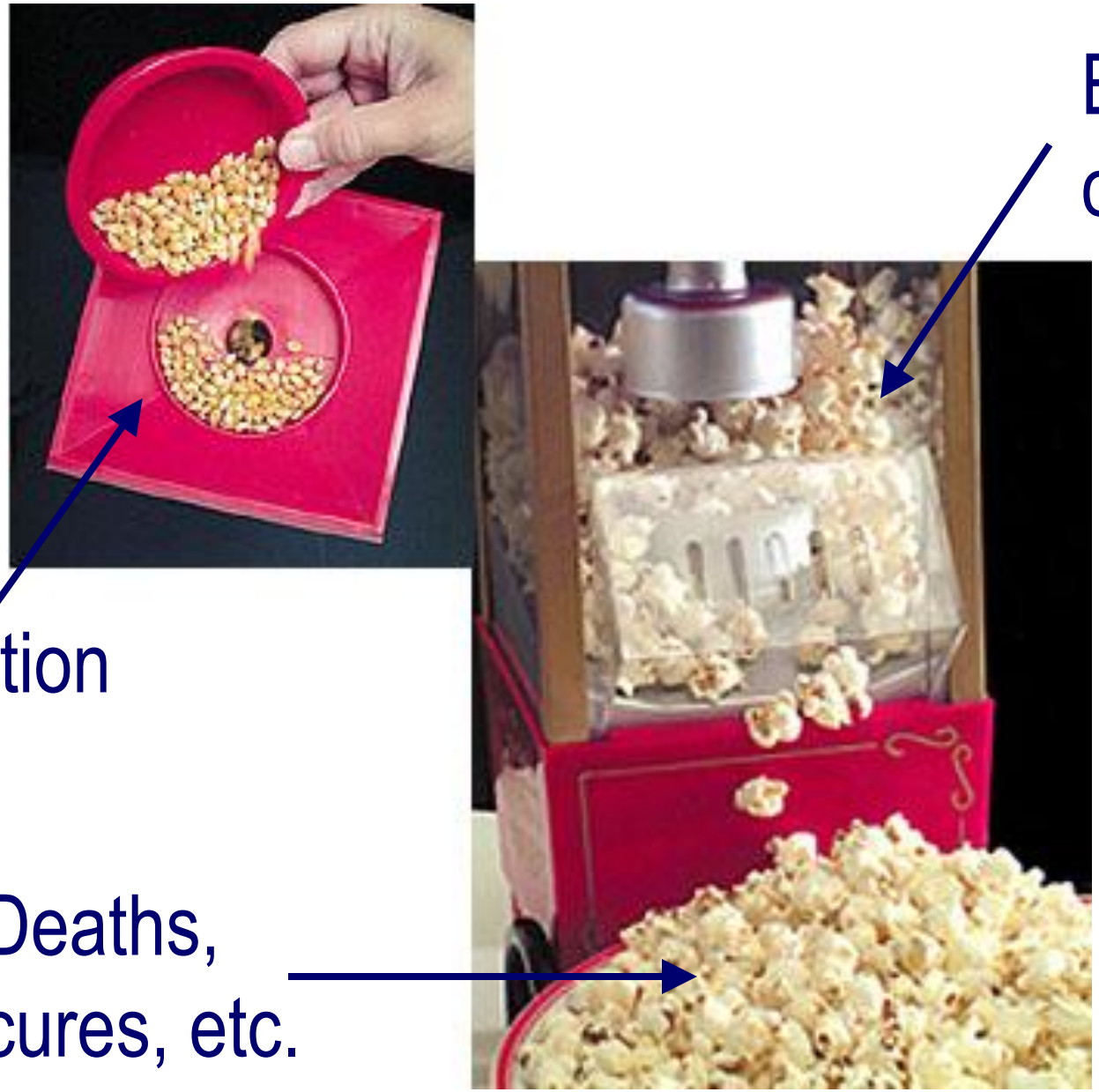
- Importance of stating units and scaling unless they are clear from the context
  - e.g., 10 per 100,000 person-years = 120 per 100,000 person-months
  - Hazards from lack of clarity

“You can never, never take anything for granted.”

Noel Hinners, vice president for flight systems at Lockheed Martin Astronautics in Denver, concerning the loss of the Martian Climate Orbiter due to the Lockheed Martin spacecraft team reporting measurements in English units whereas the orbiter’s navigation team at the Jet Propulsion Laboratory (JPL) in Pasadena, California assumed were in metric units.

Relation of incidence and prevalence

- Prevalence depends on incidence
- Higher incidence leads to higher prevalence if duration of cases does not change.
- Limitation of the bathtub analogy – flow rate needs to be expressed relative to the size of the source
- Introducing a new analogy . . .


Existing cases
Population at risk
Deaths, cures, etc.

Relation of incidence and prevalence

- Odds = probability / probability (e.g., “2 to 1” is the odds for probability of winning = 0.33 and of losing = 0.67)
- Prevalence odds = p / (1-p), where “p” is prevalence, or

  = prevalence / (1 – prevalence]
- For low prevalence, prevalence $\approx$ prevalence odds

Relation of incidence and prevalence

Under somewhat special conditions,

Prevalence odds = incidence × duration

Prevalence $\approx$ incidence × duration

Case fatality rate

- "Case fatality rate" (but it's really a proportion)
- Case fatality rate = proportion of cases who die (in a specified time interval)
- Like a "cumulative incidence of death", in cases

["incidence rate of death" in cases = "termination rate" = 1/(average survival time)]

Mortality rate

$$\text{Mortality rate} = \frac{\text{Number of deaths}}{\text{Population at risk} \times \text{Time interval}}$$

$$\text{Annual mortality rate} = \frac{\text{Number of deaths}}{\text{Mid-year population}}$$

Mortality rate (more notes)

$$\text{Mortality rate} = \frac{\text{Number of deaths}}{\text{Population at risk} \times \text{Time interval}}$$

$$\text{Annual mortality rate} = \frac{\text{Number of deaths}}{\text{Mid-year population}}$$

Mortality rates versus incidence rates

- Mortality data are more generally available
- Fatality reflects many factors, so mortality rates may not be a good surrogate of incidence rates
- Death certificate cause of death not always accurate or useful

Incidence rate versus incidence proportion

- When only care about the "bottom line" (i.e., what has happened by the end of given period), then use incidence proportion (CI).
- When want to compare to results from studies with different length of follow-up, use incidence rate (ID)
- Often, an "extended risk period" calls for a rate.

Standardization

- When objective is comparability, need to adjust for different distributions of determinants
- Strategy:
  - Analyze within each subgroup (stratum)
  - Take a weighted average across strata
  - Use same weights for all populations

(See the *Evolving Text* on www.epidemiolog.net)

Familiar example of weighted averages

- Miles per gallon - differs in highway and city
- To compare several cars, can:
  - Compare them for each type of driving separately (stratified analysis)
  - Average for each car, using one set of weights (e.g., 70% highway, 30% city)
- E.g. = 0.70 x 37 mpg + 0.30 x 18 mpg = 31.3 mpg

Comparing a Suburu and a Mazda

Juan drives a Suburu from Washington, DC to Atlanta - 400 miles highway, 100 miles city. He gets 37 mpg on highway and 18 mpg city. He uses a total of 15.1 gal., getting 33.2 mpg (500 miles/15.1 gal). His overall mpg can be expressed as a weighted average:

(400/500) x 37 mpg + (100/500) x 18 mpg

= 0.80 x 37 mpg + 0.20 x 18 mpg =33.2 mpg

Comparing a Suburu and a Mazda

Shizu drives a Mazda from Charleston SC to Atlanta - 150 miles highway, 100 miles city. She gets 40 mpg on highway and 15 mpg city. She uses a total of 8.3 gal., getting 30 mpg (250 miles/8.3 gal). Her overall mpg can be expressed as a weighted average:

(150/250) x 40 mpg + (100/250) x 15 mpg

= 0.60 x 40 mpg + 0.40 x 15 mpg =30.0 mpg

How can we compare their gas mileage?

	Juan		Shizu	
	Miles	MPG	Miles	MPG
Highway	400	37	150	40
City	100	18	100	15
Total	500	33.2	250	30.0

Total gas mileage is not comparable because weights are different

	Juan		Shizu	
	Miles	MPG	Miles	MPG
Highway	0.80	37	0.60	40
City	0.20	18	0.40	15
Total	100%	33.2	100%	30.0

By adopting a “standard” set of weights we can compare fairly

	Juan		Shizu	
	Miles	MPG	Miles	MPG
Highway	0.70	37	0.70	40
City	0.30	18	0.30	15
Total	1.0	33.2	1.0	30.0
Standardized		31.3		32.5

Comparing a Suburu and a Mazda

- Juan's Suburu:

= 0.70 x 37 mpg + 0.30 x 18 mpg =31.3 mpg

- Shizu's Mazda:

= 0.70 x 40 mpg + 0.30 x 15 mpg =32.5 mpg

The choice of weights may often affect the results of the comparison.

“I'm just glad it'll be Clark Gable
who's falling on his face
and not Gary Cooper.”

- Gary Cooper on his decision not to take the leading role in “Gone With The Wind”

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future

“A cookie store is a bad idea.
Besides, the market research reports
say America likes crispy cookies,
not soft and chewy cookies like you make.”

- Response to Debbi Fields' idea of starting
Mrs. Fields' Cookies.

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future

"Computers in the future may weigh no more than 1.5 tons."

- *Popular Mechanics*, forecasting the relentless march of science, 1949

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future

“I think there is a world market
for maybe five computers.”

-Thomas Watson, chairman of IBM, 1943

FAMOUS LAST WORDS: quotations that demonstrate the value of humility in predicting the future