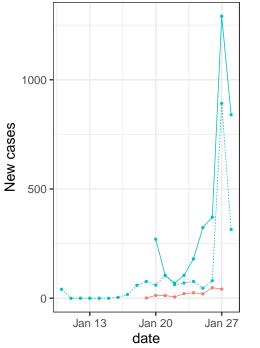
#### UNIT X Novel coronavirus



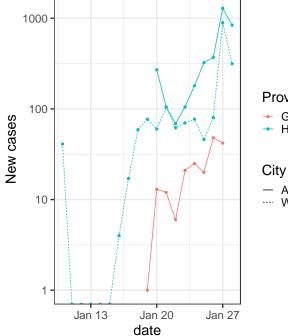
#### Province

GuangDongHuBei

#### City

— All

···· WuHan

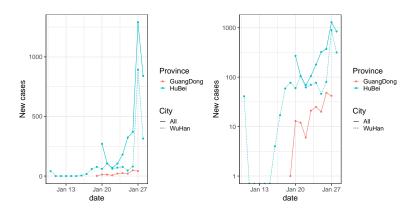


#### Province

GuangDongHuBei

ΑII

···· WuHan



► Which scale should we look at?

▶ Which scale should we look at?



- ▶ Which scale should we look at?
  - ▶ \* Both, but the log scale is more relevant

- ▶ Which scale should we look at?
  - ▶ \* Both, but the log scale is more relevant
    - **>** ,

- ▶ Which scale should we look at?
  - ▶ \* Both, but the log scale is more relevant
    - ▶ \* Focus on what individual cases are doing

- ▶ Which scale should we look at?
  - ▶ \* Both, but the log scale is more relevant
    - ► \* Focus on what individual cases are doing
  - \*

- ▶ Which scale should we look at?
  - ▶ \* Both, but the log scale is more relevant
    - \* Focus on what individual cases are doing
  - ► \* A slowdown on the log scale would be progress

- ▶ Which scale should we look at?
  - ▶ \* Both, but the log scale is more relevant
    - \* Focus on what individual cases are doing
  - ► \* A slowdown on the log scale would be progress

► What quantities do we want to look at?

▶ What quantities do we want to look at?



- ▶ What quantities do we want to look at?
  - ► \* Speed of exponential growth *r*

- ▶ What quantities do we want to look at?
  - ► \* Speed of exponential growth *r*
  - \*

- ▶ What quantities do we want to look at?
  - ► \* Speed of exponential growth *r*
  - $\blacktriangleright$  \* Finite rate of increase  $\lambda$

- ▶ What quantities do we want to look at?
  - ► \* Speed of exponential growth *r*
  - $\blacktriangleright$  \* Finite rate of increase  $\lambda$
  - \*

- What quantities do we want to look at?
  - ► \* Speed of exponential growth *r*
  - $\blacktriangleright$  \* Finite rate of increase  $\lambda$
  - ▶ \* Lifetime reproduction

- What quantities do we want to look at?
  - ► \* Speed of exponential growth *r*
  - $\blacktriangleright$  \* Finite rate of increase  $\lambda$
  - ▶ \* Lifetime reproduction

► What are the components?

▶ What are the components?

\*

- ▶ What are the components?
  - ► \* Birth rate

- ▶ What are the components?
  - ► \* Birth rate
    - \*

- ▶ What are the components?
  - ► \* Birth rate
    - ▶ \* Instantaneous rate of a case producing new cases

- ▶ What are the components?
  - ► \* Birth rate
    - ▶ \* Instantaneous rate of a case producing new cases
    - **>** 3

- What are the components?
  - ▶ \* Birth rate
    - ▶ \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]

- ▶ What are the components?
  - ▶ \* Birth rate
    - ▶ \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - \*

- ▶ What are the components?
  - ▶ \* Birth rate
    - ▶ \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - ▶ \* Death rate

- ▶ What are the components?
  - ▶ \* Birth rate
    - ▶ \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - ▶ \* Death rate
    - \*

- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - ▶ \* Death rate
    - \* Virus-centered!

- ▶ What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - ▶ \* Death rate
    - ▶ \* Virus-centered!
    - \*

- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - ▶ \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine

- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - ► \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- ► How do you think we estimate?

- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - ► \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- How do you think we estimate?
  - >

- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- How do you think we estimate?
  - ▶ \* People are estimating *r* right now from the population-level increase in disease

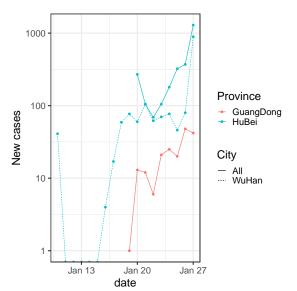
- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- ► How do you think we estimate?
  - ▶ \* People are estimating *r* right now from the population-level increase in disease
    - **>** 4

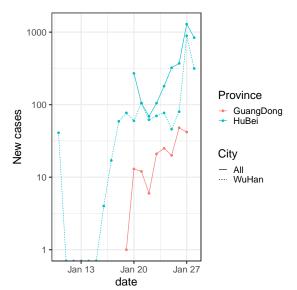
- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- ► How do you think we estimate?
  - ▶ \* People are estimating *r* right now from the population-level increase in disease
    - ► \* Then using that to estimate b

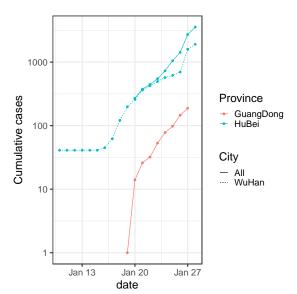
- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- How do you think we estimate?
  - ▶ \* People are estimating *r* right now from the population-level increase in disease
    - ► \* Then using that to estimate b
    - \*

- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - ► \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- ► How do you think we estimate?
  - ▶ \* People are estimating *r* right now from the population-level increase in disease
    - ► \* Then using that to estimate b
  - ► \* Models go both directions!

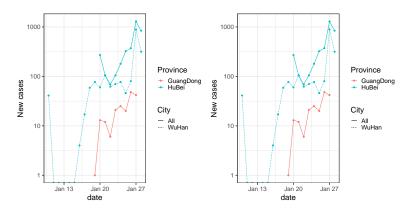
- What are the components?
  - ▶ \* Birth rate
    - \* Instantaneous rate of a case producing new cases
    - ► \* [case/(case · time]
  - \* Death rate
    - \* Virus-centered!
    - \* Rate of death, recovery, or effective quarantine
- ► How do you think we estimate?
  - ▶ \* People are estimating *r* right now from the population-level increase in disease
    - ► \* Then using that to estimate b
  - ► \* Models go both directions!







#### What's the difference?



► Why do we want this?

Why do we want this?



- ► Why do we want this?
  - ▶ \* to communicate with policy-makers or the public

- ► Why do we want this?
  - \* to communicate with policy-makers or the public
    - **▶** \*

- ► Why do we want this?
  - \* to communicate with policy-makers or the public
  - ightharpoonup \* maybe to make concrete predictions, though we could use r

- ► Why do we want this?
  - ▶ \* to communicate with policy-makers or the public
  - ightharpoonup \* maybe to make concrete predictions, though we could use r
- ► How do we calculate it?

- Why do we want this?
  - \* to communicate with policy-makers or the public
  - ightharpoonup \* maybe to make concrete predictions, though we could use r
- ► How do we calculate it?
  - \*

- ► Why do we want this?
  - ▶ \* to communicate with policy-makers or the public
  - $\triangleright$  \* maybe to make concrete predictions, though we could use r
- ► How do we calculate it?
  - \* Pick a time step (week? year?)

- Why do we want this?
  - ▶ \* to communicate with policy-makers or the public
  - $\triangleright$  \* maybe to make concrete predictions, though we could use r
- ► How do we calculate it?
  - \* Pick a time step (week? year?)
  - \*

- Why do we want this?
  - \* to communicate with policy-makers or the public
  - $\triangleright$  \* maybe to make concrete predictions, though we could use r
- How do we calculate it?
  - \* Pick a time step (week? year?)
  - ▶ \* Use a formula  $\lambda = \exp(r\Delta t)$

- ► Why do we want this?
  - \* to communicate with policy-makers or the public
  - $\triangleright$  \* maybe to make concrete predictions, though we could use r
- ► How do we calculate it?
  - \* Pick a time step (week? year?)
  - \* Use a formula  $\lambda = \exp(r\Delta t)$

 $ightharpoonup r \approx 0.14/\,\mathrm{day}$ 

- $ightharpoonup r pprox 0.14/\,\mathrm{day}$
- ▶ What is  $\lambda$ ?

- $ightharpoonup r \approx 0.14/\,\mathrm{day}$
- ▶ What is  $\lambda$ ?
  - ► At a time scale of a day?

- $ightharpoonup r pprox 0.14/\,\mathrm{day}$
- $\blacktriangleright$  What is  $\lambda$ ?
  - ► At a time scale of a day?
  - ► At a time scale of a week?

- $ightharpoonup r pprox 0.14/\,\mathrm{day}$
- $\blacktriangleright$  What is  $\lambda$ ?
  - At a time scale of a day?
  - ► At a time scale of a week?

► What is it?

- ► What is it?
  - •

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case
- ► Why do we want this?

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case
- ► Why do we want this?
  - >

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case
- Why do we want this?
  - \* An important measure of how hard the epidemic will be to stop

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case
- Why do we want this?
  - \* An important measure of how hard the epidemic will be to stop
- ► How do we calculate it?

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case
- Why do we want this?
  - \* An important measure of how hard the epidemic will be to stop
- ► How do we calculate it?
  - \*

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case
- Why do we want this?
  - \* An important measure of how hard the epidemic will be to stop
- ► How do we calculate it?
  - ▶ \*  $\mathcal{R} = b/d$ ; if we can estimate those

- ► What is it?
  - \* Expected number of new cases per case over the lifetime of a case
- Why do we want this?
  - \* An important measure of how hard the epidemic will be to stop
- ► How do we calculate it?
  - ▶ \*  $\mathcal{R} = b/d$ ; if we can estimate those

 $ightharpoonup r \approx 0.14/\,\mathrm{day}$ 

- $ightharpoonup r pprox 0.14/\,\mathrm{day}$
- $\blacktriangleright$  What is our estimate of  $\mathcal{R}$ ?

- $ightharpoonup r \approx 0.14/\,\mathrm{day}$
- $\blacktriangleright$  What is our estimate of  $\mathcal{R}$ ?
  - ▶ When average length of infection  $L = 5 \,\text{day}$ ?

- $ightharpoonup r pprox 0.14/\,\mathrm{day}$
- $\blacktriangleright$  What is our estimate of  $\mathcal{R}$ ?
  - ▶ When average length of infection  $L = 5 \,\text{day}$ ?
  - ▶ When average length of infection  $L = 10 \,\mathrm{day}$ ?

- $ightharpoonup r \approx 0.14/\,\mathrm{day}$
- $\blacktriangleright$  What is our estimate of  $\mathcal{R}$ ?
  - ▶ When average length of infection  $L = 5 \,\text{day}$ ?
  - ▶ When average length of infection  $L = 10 \,\mathrm{day}$ ?

▶ If the disease spreads around the world, most of us will get it.

- ▶ If the disease spreads around the world, most of us will get it.
- ► How many will die?

- ▶ If the disease spreads around the world, most of us will get it.
- ► How many will die?
  - ► This is a units question!

- ▶ If the disease spreads around the world, most of us will get it.
- ► How many will die?
  - ► This is a units question!
- ▶ What proportion of people with the disease are dying?

- ▶ If the disease spreads around the world, most of us will get it.
- ► How many will die?
  - This is a units question!
- What proportion of people with the disease are dying?
  - People are often not careful enough with the denominator of this proportion

- ▶ If the disease spreads around the world, most of us will get it.
- ► How many will die?
  - This is a units question!
- What proportion of people with the disease are dying?
  - People are often not careful enough with the denominator of this proportion
  - ► People with (detected) severe disease; people with (detected) recognizable disease; people who develop antibodies

- ▶ If the disease spreads around the world, most of us will get it.
- How many will die?
  - This is a units question!
- What proportion of people with the disease are dying?
  - People are often not careful enough with the denominator of this proportion
  - People with (detected) severe disease; people with (detected) recognizable disease; people who develop antibodies

► What are some reasons the virus's reproductive number may go down as it spreads?

► What are some reasons the virus's reproductive number may go down as it spreads?

\*

- ► What are some reasons the virus's reproductive number may go down as it spreads?
  - ► \* People react by changing behaviour

- ► What are some reasons the virus's reproductive number may go down as it spreads?
  - ► \* People react by changing behaviour
  - **>** \*

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune
  - \*

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune
  - \* Vaccination or treatment

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune
  - \* Vaccination or treatment
- ► Are there any reasons it might go *up*?

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune
  - \* Vaccination or treatment
- Are there any reasons it might go up?
  - \*

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune
  - \* Vaccination or treatment
- Are there any reasons it might go up?
  - \* Evolution

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - ▶ \* People die or become immune
  - \* Vaccination or treatment
- Are there any reasons it might go up?
  - \* Evolution
  - \*

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune
  - \* Vaccination or treatment
- Are there any reasons it might go up?
  - \* Evolution
  - ► \* One way evolution sometimes increases  $\mathcal{R}$  is by decreasing the fatality proportion

- What are some reasons the virus's reproductive number may go down as it spreads?
  - \* People react by changing behaviour
  - \* People die or become immune
  - \* Vaccination or treatment
- Are there any reasons it might go up?
  - \* Evolution
  - ► \* One way evolution sometimes increases  $\mathcal{R}$  is by decreasing the fatality proportion

► How is the disease transmitted?

- ► How is the disease transmitted?
  - Probably air droplets and contaminated surfaces

- ► How is the disease transmitted?
  - Probably air droplets and contaminated surfaces
- ► Can it be transmitted before symptoms start?

- ► How is the disease transmitted?
  - Probably air droplets and contaminated surfaces
- ► Can it be transmitted before symptoms start?
  - Probably

- ► How is the disease transmitted?
  - Probably air droplets and contaminated surfaces
- Can it be transmitted before symptoms start?
  - Probably
- ▶ What is the likely age distribution of serious cases?

- ► How is the disease transmitted?
  - Probably air droplets and contaminated surfaces
- Can it be transmitted before symptoms start?
  - Probably
- What is the likely age distribution of serious cases?
  - Probably mostly elderly people

- ► How is the disease transmitted?
  - Probably air droplets and contaminated surfaces
- Can it be transmitted before symptoms start?
  - Probably
- What is the likely age distribution of serious cases?
  - Probably mostly elderly people