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Population density and the spread of COVID-19

Prof. Oliver Johnson, School of Maths
Twitter: @BristOliver

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How to compare COVID-19 deaths between countries?

- Answer: very carefully, and not yet.
- Data collected at different speeds, to different standards.
- But if you must . . .
- Now epidemic becoming mature, per capita is better.
- If everyone in Ireland was infected:

  5 million population x 1% fatality rate = 50,000 deaths.
- So Ireland could never have as many deaths as USA.

Demographics

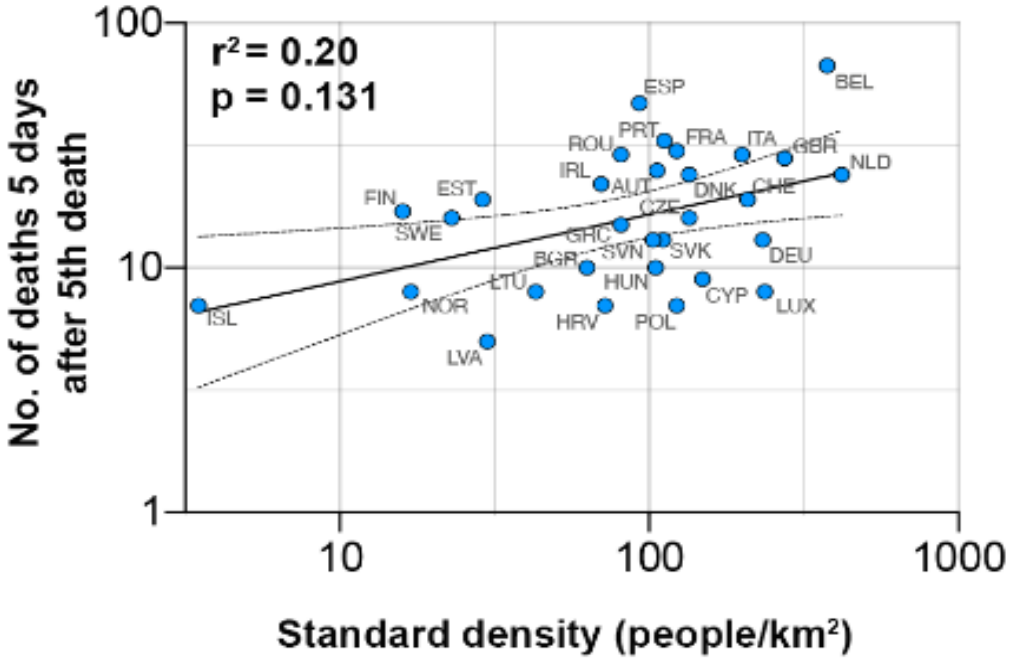
- Not all patients are alike.
- Age, obesity, diabetes etc are significant risk factors.
- %age of people affected by them impacts death rates.
- Not all countries on the same playing field.
- What else might make a difference?

Population density and spread

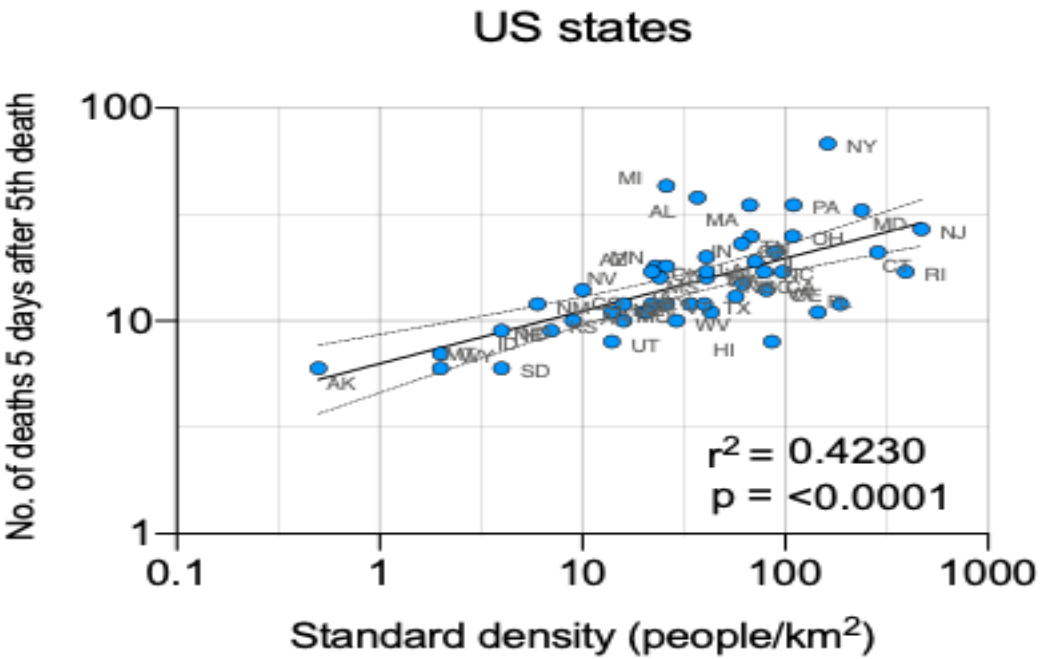
- Seems intuitive that population density matters.
- COVID-19 is a disease of cities.
- More people, harder to social distance, virus should spread faster.
- Test this by comparing European countries.
- Have data for population density.
- Measure rate of spread by

  e.g. `total of deaths 5 days after reaching 5 deaths'.

Results not convincing – but look at Spain



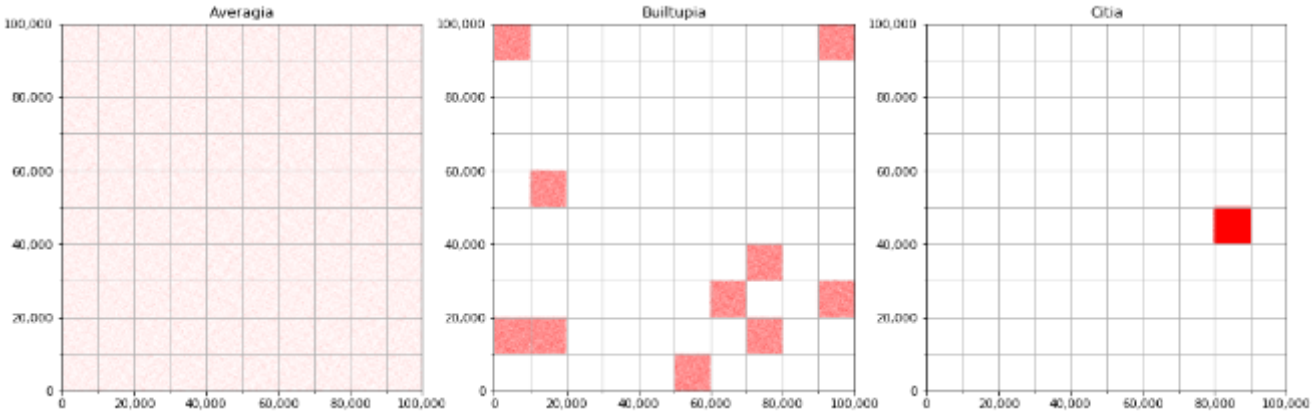
Does better for US States – but look at NY



Standard population density not right measure?

- Standard population density ρ_S : people/km^2
- It says “pick a random point in space, how many people near?”
- But virus doesn't do that: “pick a random person, how many people near?”
- Not the same thing at all (think about New York state).
- Need to measure lived experience of population density.

Toy Example



- Consider 100,000 people living in a 10km x 10km region
- Spread evenly (Averagia), 10 towns (Builtupia), 1 city (Citia)
- Different daily experience, and different virus risk

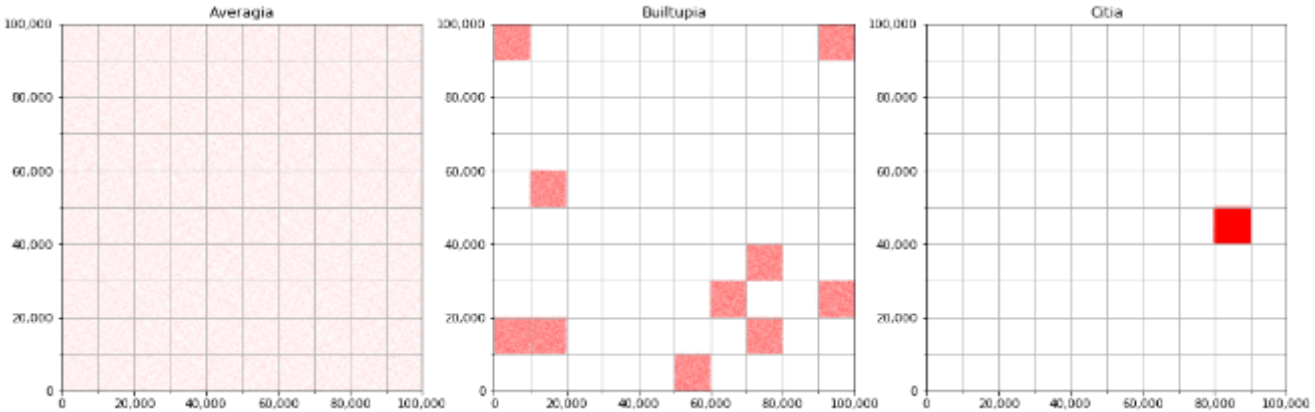
Lived population density

- Have access to gridded population (e.g. 1km^2 scale via WorldPop database).
- Calculate two different measures of lived density:
  - a) lived density ρ_N introduced by Rae (ignore empty regions)
  - b) population-weighted (quadratic) density ρ_W introduced by Craig

$$\rho_W = \frac{1}{n} \sum_{i=1}^{M} \frac{n_i^2}{A_i}$$

- These measures give more intuitive values of density.

Toy Example (slight return)

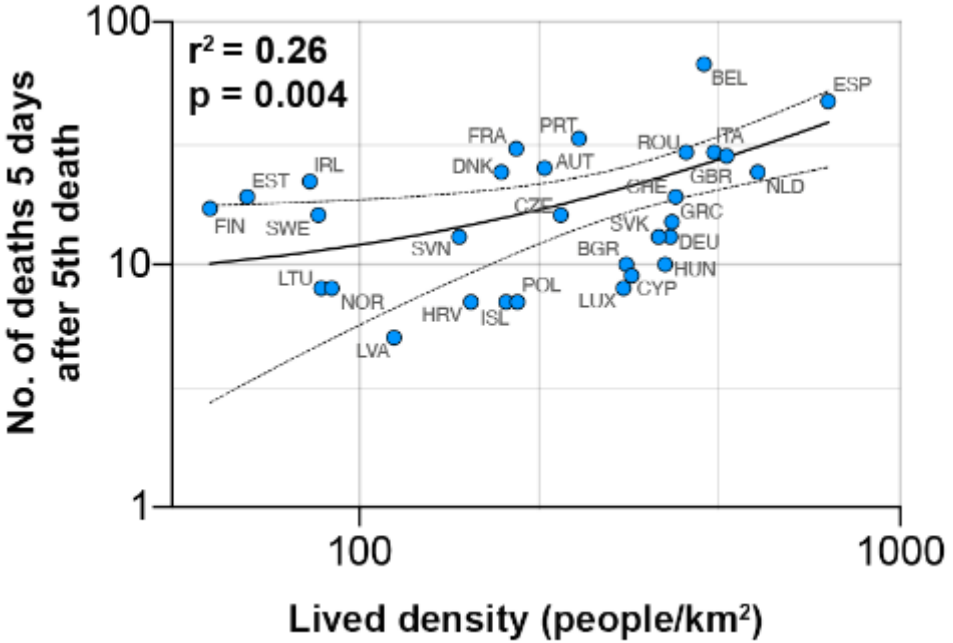


- Averagia: ρ_S = 1,000, $\rho_N = \rho_W$ = 1,000
- Builtupia: ρ_S = 1,000, $\rho_N = \rho_W$ = 10,000
- Citia: ρ_S = 1,000, $\rho_N = \rho_W$ = 100,000

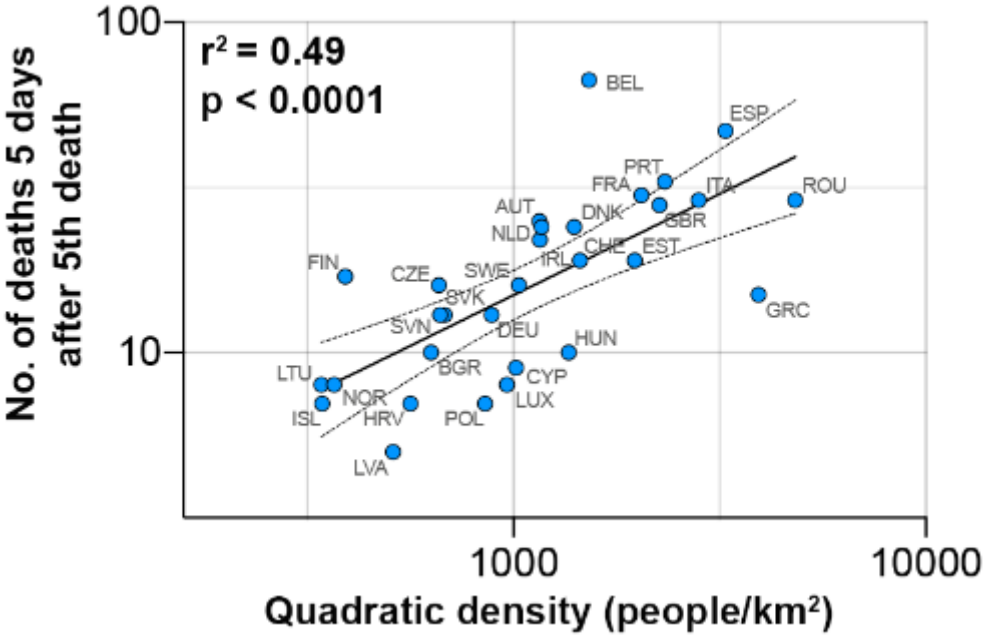
Densities for sample of European countries

Country	Standard ρ_S	Lived ρ_N	Weighted ρ_W
Spain	93	737	3273
UK	274	478	2263
France	123	195	2044
Germany	233	376	885
Sweden	23	84	1031
Ireland	70	81	1161
Greece	81	379	3930
Belgium	376	434	1524

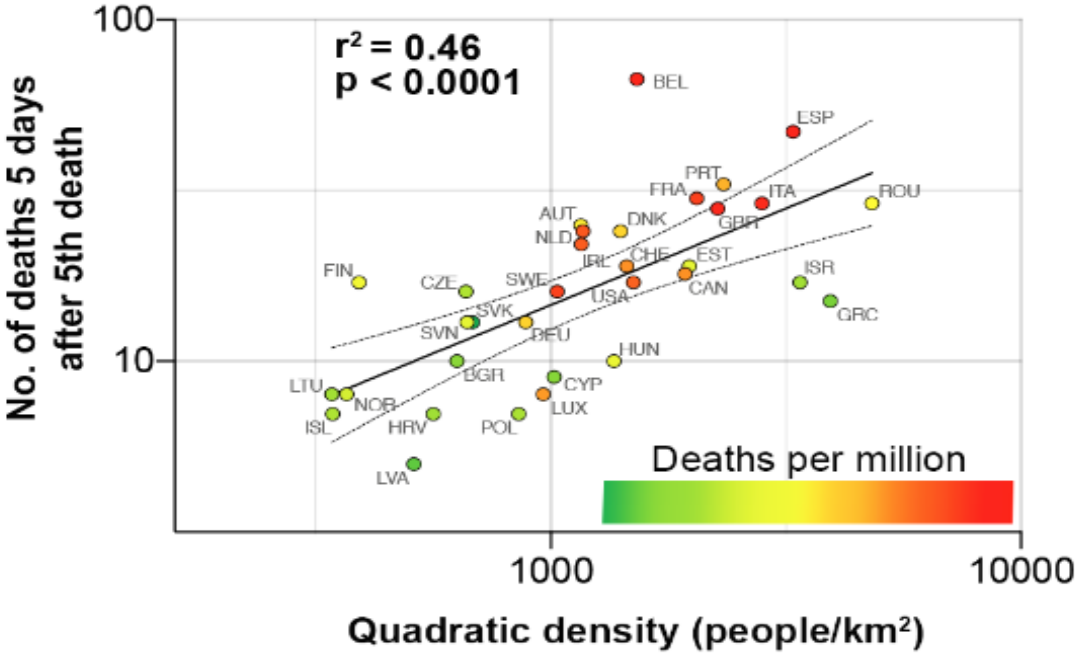
Lived density ρ_N better (26% of variation)



Quadratic ρ_W even better (49% of variation)



Early spread has a big effect on total deaths



Conclusions

- Non-standard measures of population density help explain spread of COVID-19.
- Should be taken into account in any final comparisons.
- Doesn’t tell the whole story (works within, not between, continents).
- Overall death statistics should still be interpreted with caution.

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Preprint at arxiv.org/abs/2005.01167

Thanks to co-authors:

Patrick Garland, Dave Babbitt, Maksym Bondarenko, Alessandro Sorichetta, Andrew J. Tatem

Data from WorldPop Project

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