# Patterns of excess mortality and life expectancy losses across developed countries


## Vladimir M. Shkolnikov

This presentation includes research results from studies co-authored with:

D.A.Jdanov, N.Islam, I.Klimkin, D.A.Leon, A. Alustiza Galarza, S.A.Timonin, E.M.Andreev, I.Danilova, M.McKee



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MAX PLANCK INSTITUTE FOR DEMOGRAPHIC RESEARCH

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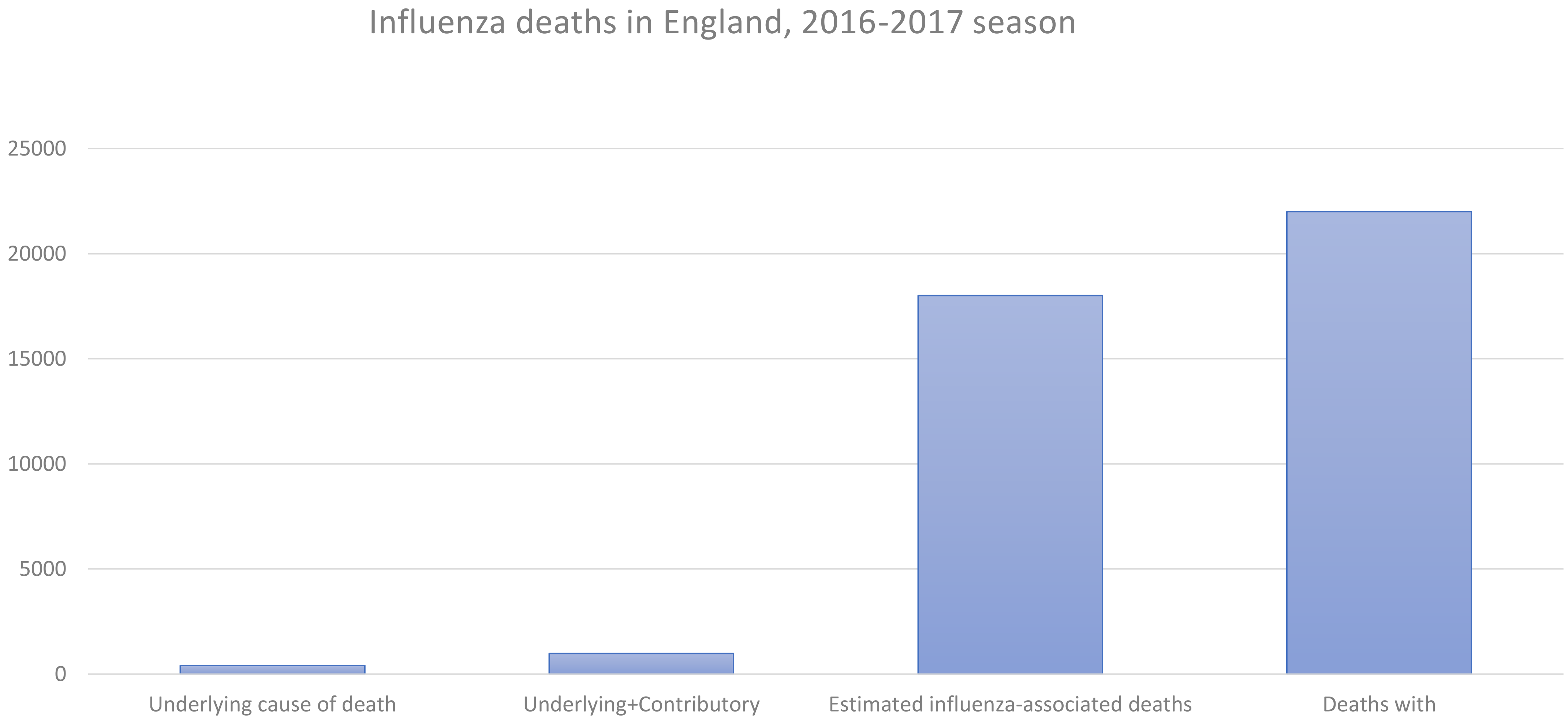
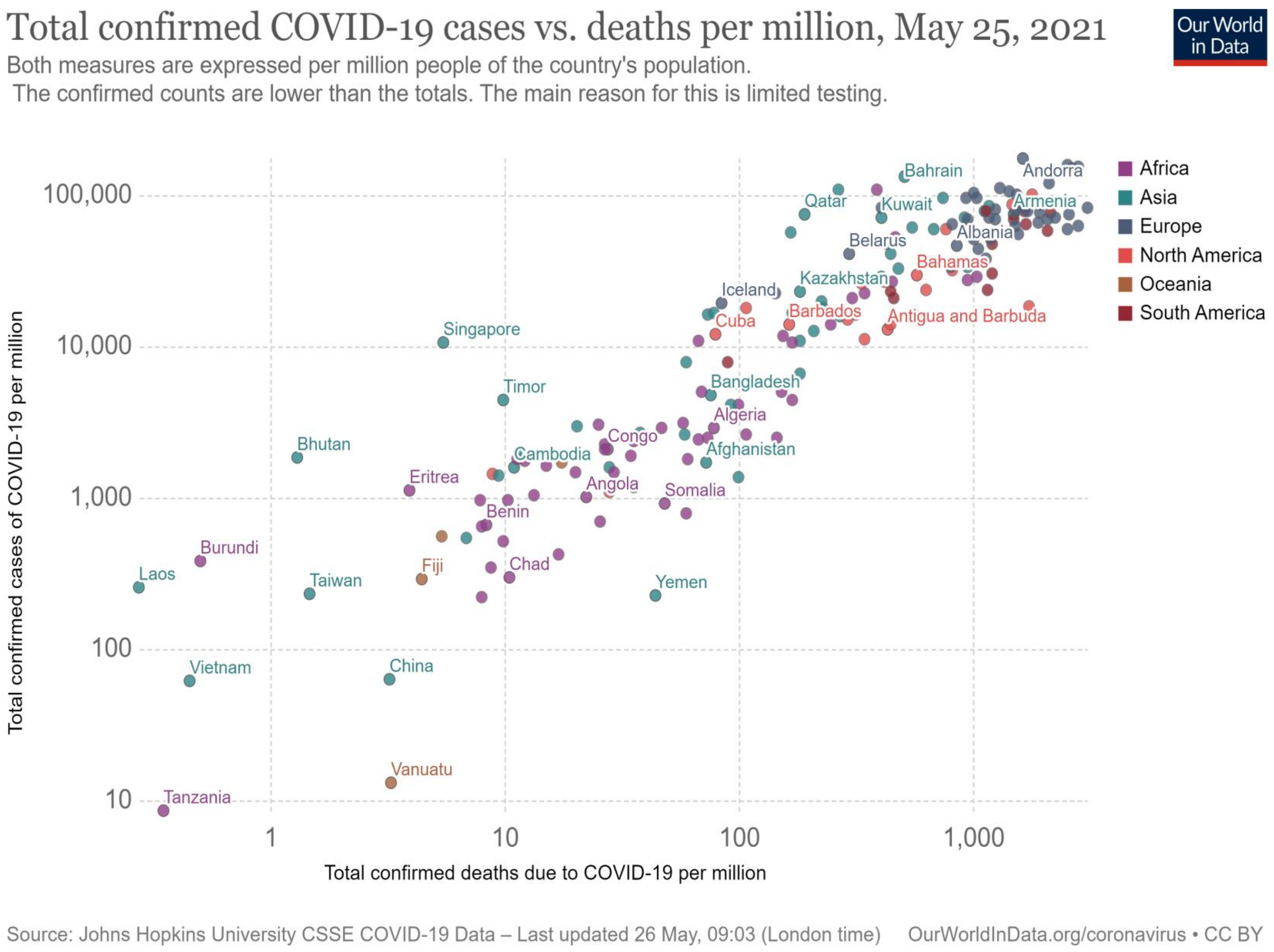
# Excess mortality: method for measuring mortality impacts of epidemics

# Influenza: deaths "from" or deaths "with"




*From earlier presentation by Danilova, Shkolnikov, Jdanov. HSE Webinar: COVID-19: Quantification*

# Cases of COVID-19 vs. deaths from COVID-19 across countries




*From earlier presentation by Danilova, Shkolnikov, Jdanov. HSE Webinar: COVID-19: Quantification*

# Problems with data on causes of death

- It has been known since the 1970s that influenza and respiratory diseases always constitute a minor part of winter mortality elevations during influenza epidemics. This completely agrees with the WHO rules for diagnostics and coding of underlying (main) cause of death.
- During the COVID-19 pandemic, registration of the disease as the underlying COD has been greatly varying across countries and time. To increase completeness of registration of SARS-CoV2 related deaths, the WHO released a recommendation for a prioritized registration of COVID-19 as an underlying cause of death.
  WHO, 16 Apr 2020: A death due to COVID-19 is defined for surveillance purposes as a death resulting from a clinically compatible illness, in a probable or confirmed COVID-19 case, unless there is a clear alternative cause of death that cannot be related to COVID disease (e.g. trauma).
- This has not solved the problems. Implausibly great variations in cases, deaths, and deaths-to-cases ratio across countries are sustaining.

# Excess mortality assessment as a strong alternative to data on causes of death

**Correspondence**

## COVID-19: a need for real-time monitoring of weekly excess deaths

The first-line epidemiological response to coronavirus disease 2019 (COVID-19) requires estimation of key parameters, including case fatality risk,

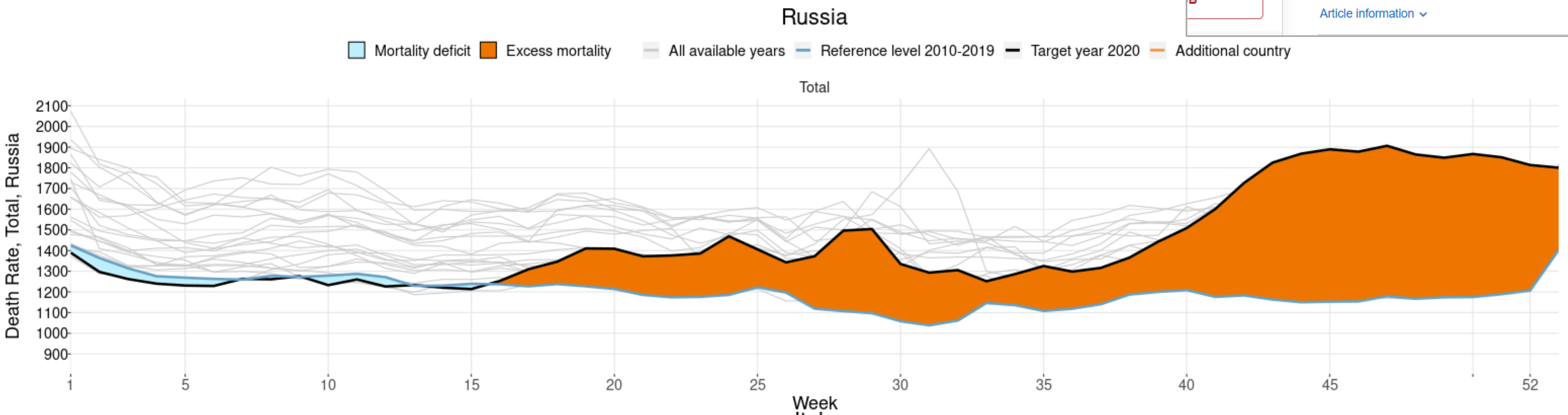
> We therefore urge all national authorities who can collate counts of weekly deaths to expedite the publication of these data and place them in the public domain. The dissemination of this information should be done within 3–4 weeks of the period of observation. At a minimum, tabulations by sex and 5-year age groups are essential.

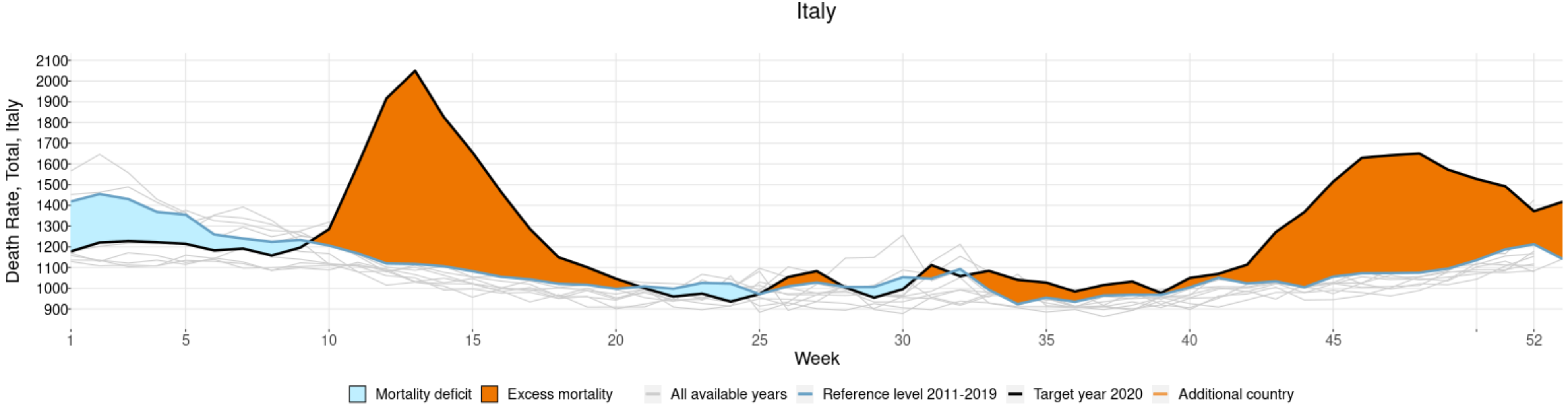
Published Online
April 22, 2020
https://doi.org/10.1016/S0140-6736(20)30933-8

**Source : Leon DA, Shkolnikov VM, Smeeth L, Magnus P, Pechholdová M, Jarvis CI. COVID-19: a need for real-time monitoring of weekly excess deaths. *The Lancet***

Submitted to *The Lancet* 23 March 2020, published 22 April 2020. A shorter version of the Letter was published by the *Financial Times* 6th of April 2020

# Excess mortality = excess in observed mortality relative to baseline level estimated from the past mortality experience

# STMF data series in the HMD – the most reliable data source for estimation of excess mortality

https://mpidr.shinyapps.io/stmortality/

HMD
Human Mortality Database
HMD Twitter: User's Guide:

Country or region: Italy
Target year: 2020
Show other years
Measure: Age-specific Death Rate, Ages 85+
Sex: Total, Female, Male
Reference period: Continuous / Multi-year
Reference years: 2011 – 2019 (2021)
Reference level: Week-specific Trends
- Week-specific Averages
- Week-specific Trends
- Week-specific Lower Quartiles
- Yearly Average-week
- Summer Average-week
- Yearly Lower-quartile-week

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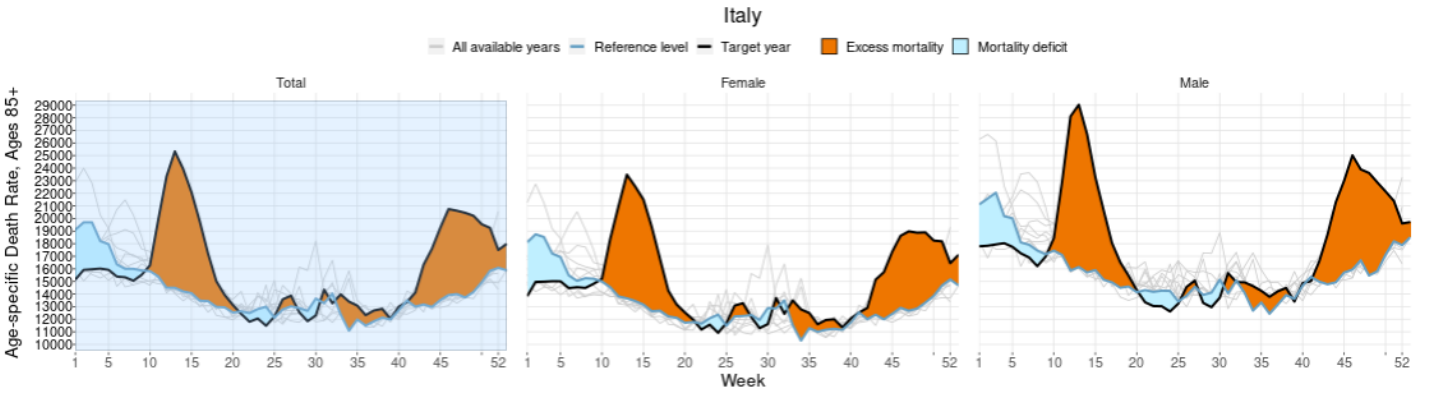
## Short-term Mortality Fluctuations

The most recent update is: 2021-04-30
The project's website: Human Mortality Database www.mortality.org hmd@mortality.org
Research article DOI: 10.1371/journal.pone.0246663 || UX/UI and public GitHub repository by László Németh
Data for the last available weeks is preliminary and may be incomplete, please refer to the country-specific metadata for details.




Summary statistics
The selection in Italy is between weeks 1 and 52 for the year 2020 compared to the period of 2011-2019.

Clicked point information

| Sex | Difference | Average Death Rate | Average, Target | Average, Reference | ADR/Reference (%) |
|---|---|---|---|---|---|
| Total | Mortality deficit | -1396.86 | 13966.10 | 15362.95 | -9.09 |
| Total | Excess mortality | 3438.10 | 16850.23 | 13412.13 | 25.63 |
| Female | Mortality deficit | -1412.82 | 13284.08 | 14696.91 | -9.61 |
| Female | Excess mortality | 3134.69 | 15686.44 | 12551.75 | 24.97 |
| Male | Mortality deficit | -1398.81 | 15265.61 | 16664.42 | -8.39 |
| Male | Excess mortality | 4134.85 | 19317.48 | 15182.63 | 27.23 |

**Human Mortality Database**

**www.mortality.org**

www.nature.com/scientificdata

**Sci Data. 2021;8:235**

OPEN
DATA DESCRIPTOR

### The short-term mortality fluctuation data series, monitoring mortality shocks across time and space


Dmitri A. Jdanov[1,2], Ainhoa Alustiza Galarza[1], Vladimir M. Shkolnikov[1,2], Domantas Jasilionis[1,3], László Németh[1], David A. Leon[2,4,5], Carl Boe[6] & Magali Barbieri[6,7]



**The COVID-19 pandemic has revealed substantial coverage and quality gaps in existing international and national statistical monitoring systems. It is striking that obtaining timely, accurate, and comparable across countries data in order to adequately respond to unexpected epidemiological threats is very challenging. The most robust and reliable approach to quantify the mortality burden due to short-term risk factors is based on estimating weekly excess deaths. This approach is more reliable than monitoring deaths with COVID-19 diagnosis or calculating incidence or fatality rates affected by numerous problems such as testing coverage and comparability of diagnostic approaches. In response to the emerging data challenges, a new data resource on weekly mortality has been established. The Short-term Mortality Fluctuations (STMF, available at www.mortality.org) data series is the first international database providing open-access harmonized, uniform, and fully documented data on weekly all-cause mortality. The STMF online vizualisation tool provides an opportunity to perform a quick assessment of the excess weekly mortality in one or several countries by means of an interactive graphical interface.**


**Background & Summary**

Effective public health responses to epidemics have always required timely and reliable monitoring of the situation. During the last decades, there have been numerous short-term mortality peaks related to influenza, heat waves or winter cold, natural or man-made disasters that have been large enough to show signals at the national level. For example, in recent years seasonal influenza outbreaks in 2014–15, 2016–17, and 2017–18 resulted in substantial mortality elevations in many countries. However, it has taken the disaster of the 2019 SARS-Cov-2 (COVID-19) pandemic to make clear how inadequate existing systems have been for generating rapidly open and comparable international data that are both timely and accurate. Such data are needed for the first-line epidemiological and policy response and for projecting the probable trajectory of epidemic spread. At the beginning of the pandemic, the monitoring of the rapidly changing situation was a major challenge for statistical and public health systems. Information about key parameters of the pandemic such as the incidence of new SARS-CoV-2 cases and deaths from COVID-19 were biased by large differences in approaches to testing SARS-CoV-2 and recoding of COVID-19 as a cause of death[1]. While some countries tend to attribute to COVID-19 all or nearly all deaths of those with positive tests for the virus, others applied more conservative approaches with an emphasis on pre-existing co-morbidities. Unfortunately, this huge disadvantage of published data on confirmed cases and deaths due to epidemic diseases (e.g. COVID-19) is underappreciated in the wider research community.

An alternative approach to measuring the population impact of short-term mortality fluctuations such as that due to COVID-19 is quantifying the all-cause mortality burden based on estimating weekly excess deaths relative to what would be expected based on the experience of previous years. This side-steps the serious methodological

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RESEARCH ARTICLE

### An open-sourced, web-based application to analyze weekly excess mortality based on the Short-term Mortality Fluctuations data series


László Németh, Dmitri A. Jdanov, Vladimir M. Shkolnikov



Published: February 5, 2021 • https://doi.org/10.1371/journal.pone.0246663




Abstract

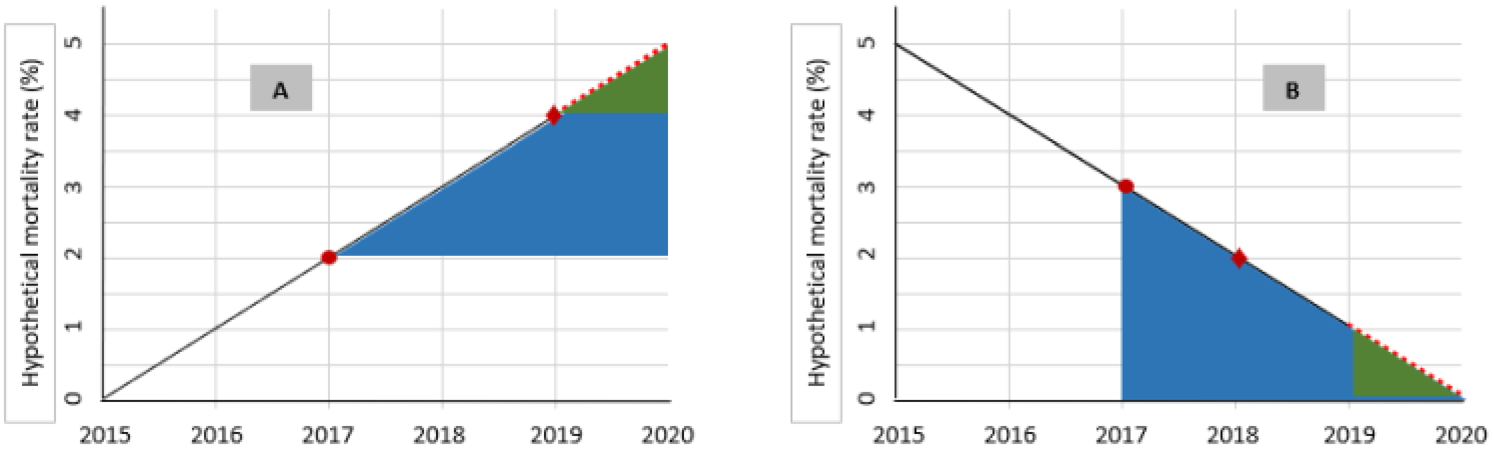

The COVID-19 pandemic stimulated the interest of scientists, decision makers and the general public in short-term mortality fluctuations caused by epidemics and other natural or man-made disasters. To address this interest and provide a basis for further research, in May 2020, the Short-term Mortality Fluctuations data series was launched as a new section of the Human

# Important choices in the excess mortality estimation

- Measure of mortality: Deaths, CDR, **SDR, LE,** YLL, …
- Method for baseline mortality: Average, **Average + Trend**, Harmonics + Trend, **Lee-Carter**, …
- Metrics of the deviation: **absolute difference**, relative ratio
- Reference period: 2019, 2015-19, 2016-19, 2012-19, 2010-19, **2005-19**,
- Time series' units: **years**, months, **w**
Mortality peaks during the reference period: **included**, excluded

**Systematic analysis:** Nepomuceno M., Klimkin I., Jdanov D.A., Alustiza Galarza A. and Shkolnikov V.M. Sensitivity of excess mortality due to the COVID-19 pandemic to the choice of the mortality index, method, reference period, and the time unit of death series. *Population and Development Review*, 2021 (In press)

Panel-I: Graphical presentation of potential incorrect conclusion on excess mortality in the context of an increasing or decreasing trend




Source: Islam N., Jdanov D.A., Shkolnikov V.M., Khunti K., Kawachi I., White M., Lewington S., Lacey B. Effects of covid-19 pandemic on life expectancy and premature mortality in 2020: time series analysis in 37 countries. *BMJ* 2021;375:e066768 http://dx.doi.org/10.1136/bmj-2021-066768

Panel B of the figure demonstrates that assumptions of the baseline mortality in 2020 being equal to mortality in 2019 or equal to the average mortality in 2016-19 lead to underestimation of the excess mortality in presence of the general mortality decline. Such decline is observed in almost all countries.

# Excess mortality and life expectancy losses across countries in 2020

# Studies published in the BMJ in May and November 2021

RESEARCH

*BMJ* 2020;370:m2743

## Excess deaths associated with covid-19 pandemic in 2020: age and sex disaggregated time series analysis in 29 high income countries

Nazrul Islam,[1,2] Vladimir M Shkolnikov,[3,4] Rolando J Acosta,[5] Ilya Klimkin,[4] Ichiro Kawachi,[6] Rafael A Irizarry,[5,7] Gianfranco Alicandro,[8] Kamlesh Khunti,[9,10] Tom Yates,[9,11] Dmitri A Jdanov,[3,4] Martin White,[2] Sarah Lewington,[1,12] Ben Lacey[1]

**ABSTRACT**

**OBJECTIVE**

To estimate the direct and indirect effects of the covid-19 pandemic on mortality in 2020 in 29 high income countries with reliable and complete age and sex disaggregated mortality data.

**DESIGN**

Time series study of high income countries.

**SETTING**

Austria, Belgium, Czech Republic, Denmark, England and Wales, Estonia, Finland, France, Germany, Greece, Hungary, Israel, Italy, Latvia, Lithuania, the Netherlands, New Zealand, Northern Ireland, Norway, Poland, Portugal, Scotland, Slovakia, Slovenia, South Korea, Spain, Sweden, Switzerland, and United States.

**PARTICIPANTS**

model that accounts for temporal trends and seasonal variability in mortality.

**RESULTS**

An estimated 979 000 (95% confidence interval 954 000 to 1 001 000) excess deaths occurred in 2020 in the 29 high income countries analysed. All countries had excess deaths in 2020, except New Zealand, Norway, and Denmark. The five countries with the highest absolute number of excess deaths were the US (458 000, 454 000 to 461 000), Italy (89 100, 87 500 to 90 700), England and Wales (85 400, 83 900 to 86 800), Spain (84 100, 82 800 to 85 300), and Poland (60 100, 58 800 to 61 300). New Zealand had lower overall mortality than expected (−2500, −2900 to −2100). In many countries, the estimated number of excess deaths substantially exceeded the number of reported deaths from

RESEARCH

*BMJ* 2021;375:e066768

## Effects of covid-19 pandemic on life expectancy and premature mortality in 2020: time series analysis in 37 countries

Nazrul Islam,[1] Dmitri A Jdanov,[2,3] Vladimir M Shkolnikov,[2,3] Kamlesh Khunti,[4,5] Ichiro Kawachi,[6] Martin White,[7] Sarah Lewington,[1,8] Ben Lacey[1]

**ABSTRACT**

**OBJECTIVE**

To estimate the changes in life expectancy and years of life lost in 2020 associated with the covid-19 pandemic.

**DESIGN**

Time series analysis.

**SETTING**

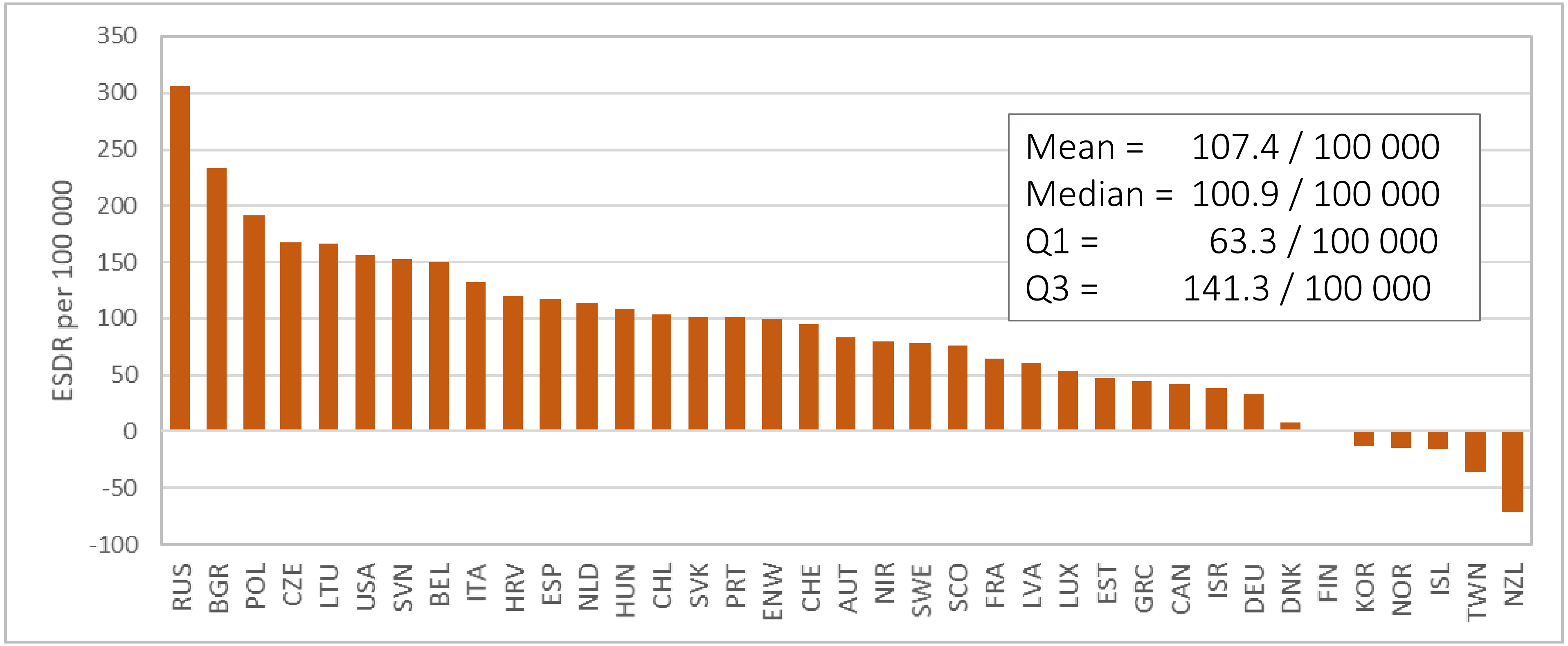
37 upper-middle and high income countries or regions with reliable and complete mortality data.

**PARTICIPANTS**

Annual all cause mortality data from the Human Mortality Database for 2005-20, harmonised and disaggregated by age and sex.

a change in life expectancy in Denmark, Iceland, and South Korea. The highest reduction in life expectancy was observed in Russia (men: −2.33, 95% confidence interval −2.50 to −2.17; women: −2.14, −2.25 to −2.03), the United States (men: −2.27, −2.39 to −2.15; women: −1.61, −1.70 to −1.51), Bulgaria (men: −1.96, −2.11 to −1.81; women: −1.37, −1.74 to −1.01), Lithuania (men: −1.83, −2.07 to −1.59; women: −1.21, −1.36 to −1.05), Chile (men: −1.64, −1.97 to −1.32; women: −0.88, −1.28 to −0.50), and Spain (men: −1.35, −1.53 to −1.18; women: −1.13, −1.37 to −0.90). Years of life lost in 2020 were higher than expected in all countries except Taiwan, New Zealand, Norway, Iceland, Denmark, and South Korea.

# Excess SDR per 100 000 in 37 countries, both sexes




Mortality measure = SDR

Method for the baseline = Average + Trend

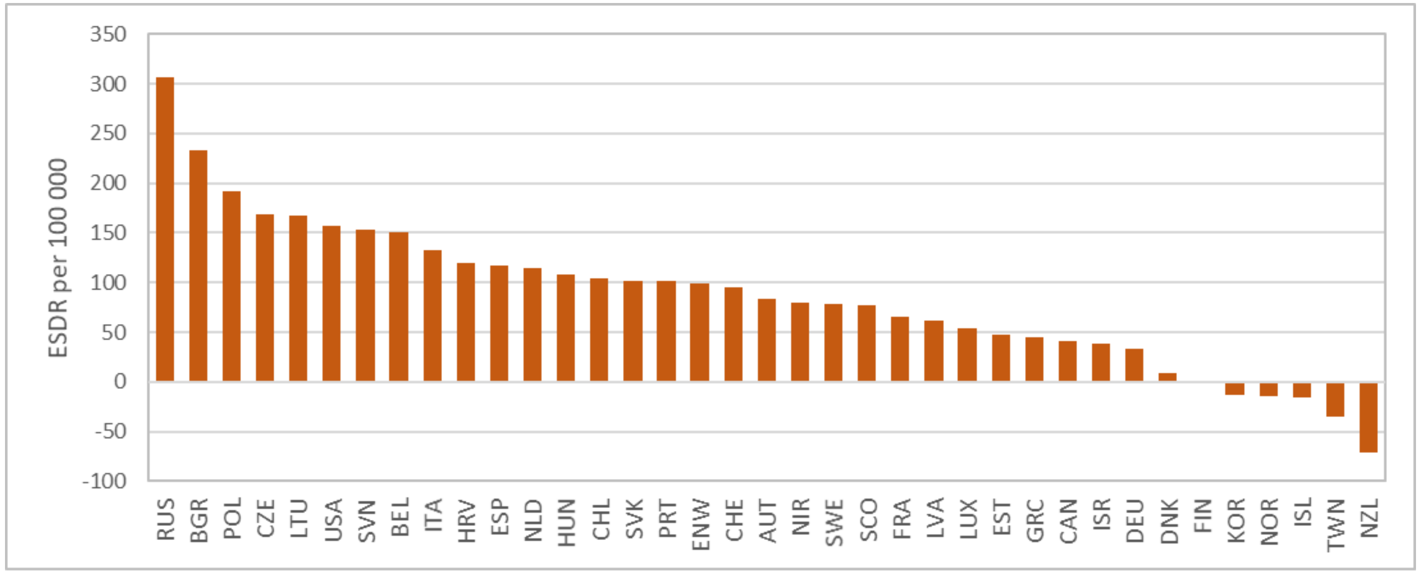
Metrics = $SDR_{obs} - SDR_{baseline}$

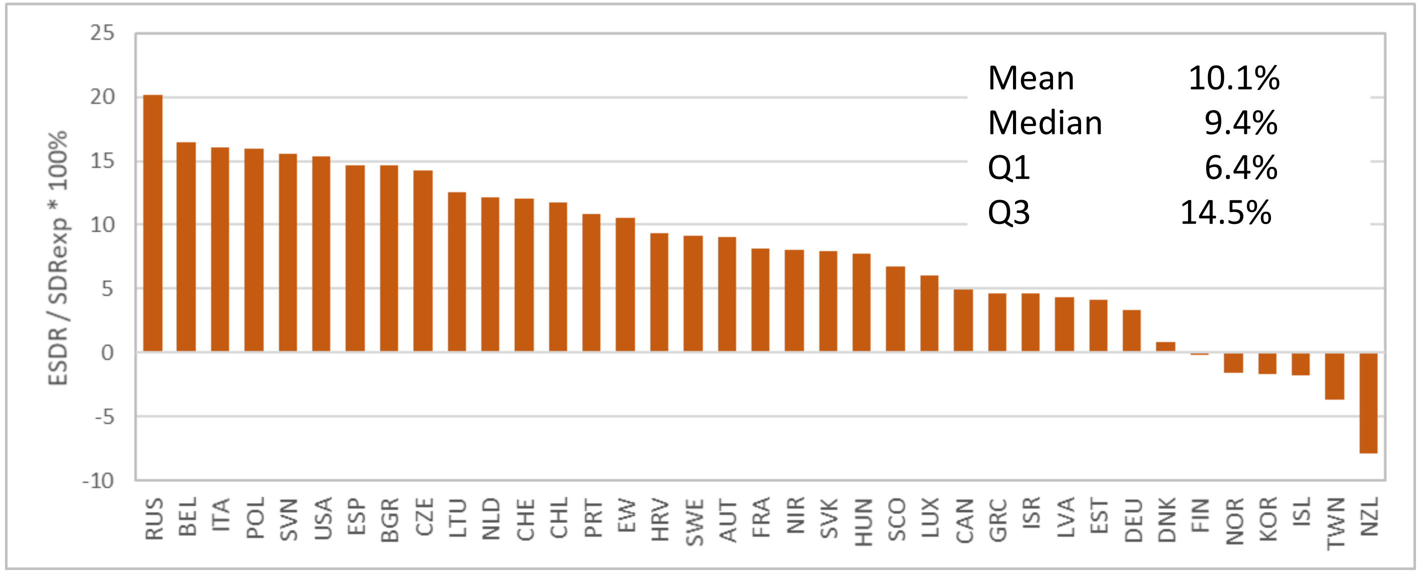
Ref. period = 2005-2019

Sources for slides 12-19: author's calculations from the observed and baseline death rates in 2020 by age and sex from the study Islam N. et al. http://dx.doi.org/10.1136/bmj-2021-066768. Weekly mortality data from STMF.

SDR-excess.xlsx/ESDRabs. Data: SDR-ESDR-aggr-ages-2020.dta. ESDR-SDR-scatter.do; SDR-obs-exp-2020.R

# ESDR: absolute *vs.* relative

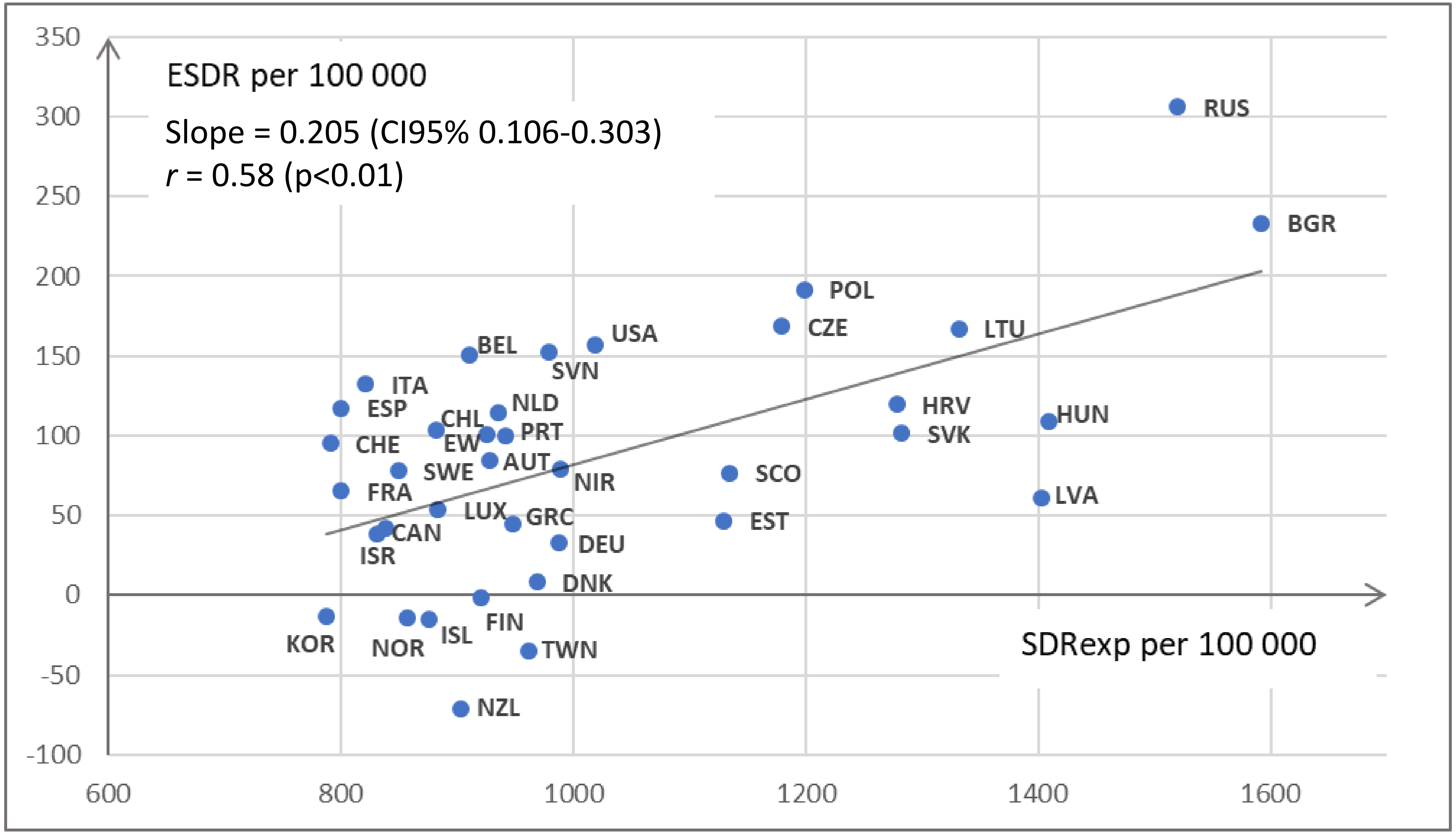



| | | Spearman RC = | 0.946 |
|---|---|---|---|
| | Rank_ESDR | Rank_REL | Diff |
| AUT | 19 | 18 | 1 |
| BEL | 8 | 2 | 6 |
| BGR | 2 | 8 | -6 |
| CAN | 28 | 25 | 3 |
| CHE | 18 | 12 | 6 |
| CHL | 14 | 13 | 1 |
| CZE | 4 | 9 | -5 |
| DEU | 30 | 30 | 0 |
| DNK | 31 | 31 | 0 |
| ESP | 11 | 7 | 4 |
| EST | 26 | 29 | -3 |
| FIN | 32 | 32 | 0 |
| FRA | 23 | 19 | 4 |
| EW | 17 | 15 | 2 |
| NIR | 20 | 20 | 0 |
| SCO | 22 | 23 | -1 |
| GRC | 27 | 26 | 1 |
| HRV | 10 | 16 | -6 |
| HUN | 13 | 22 | -9 |
| ISL | 35 | 35 | 0 |
| ISR | 29 | 27 | 2 |
| ITA | 9 | 3 | 6 |
| KOR | 33 | 34 | -1 |
| LTU | 5 | 10 | -5 |
| LUX | 25 | 24 | 1 |
| LVA | 24 | 28 | -4 |
| NLD | 12 | 11 | 1 |
| NOR | 34 | 33 | 1 |
| NZL | 37 | 37 | 0 |
| POL | 3 | 4 | -1 |
| PRT | 16 | 14 | 2 |
| RUS | 1 | 1 | 0 |

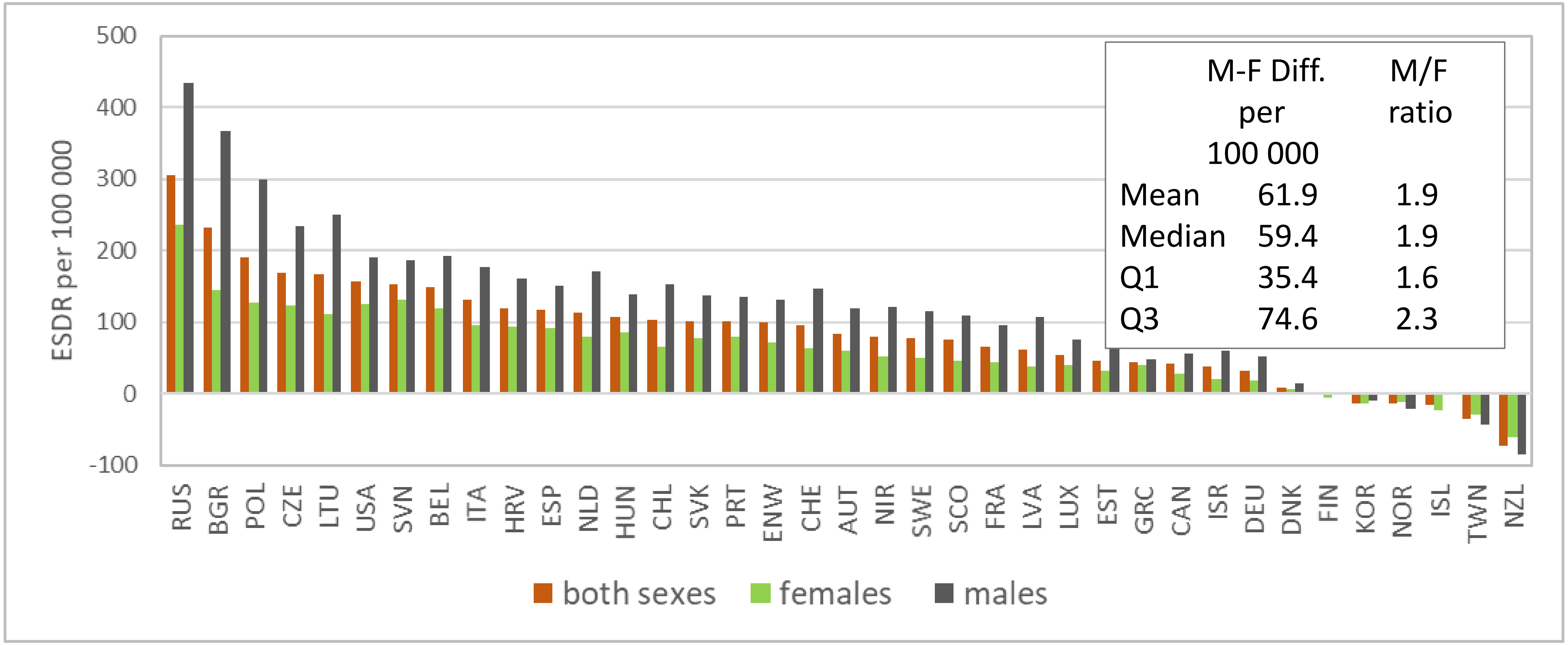
Sources. SDR-excess.xlsx/ESDRrel. Data: SDR-ESDR-aggr-ages-2020.dta. ESDR-SDR-scatter.do; SDR-obs-exp-2020.R

# Mortality excess tended to be larger in higher-mortality countries: ESDR *vs.* $SDR_{baseline}$




SDR-excess.xlsx/ESDRvsSDRexp. Data: SDR-ESDR-aggr-ages-2020.dta. ESDR-SDR-scatter.do; SDR-obs-exp-2020.R

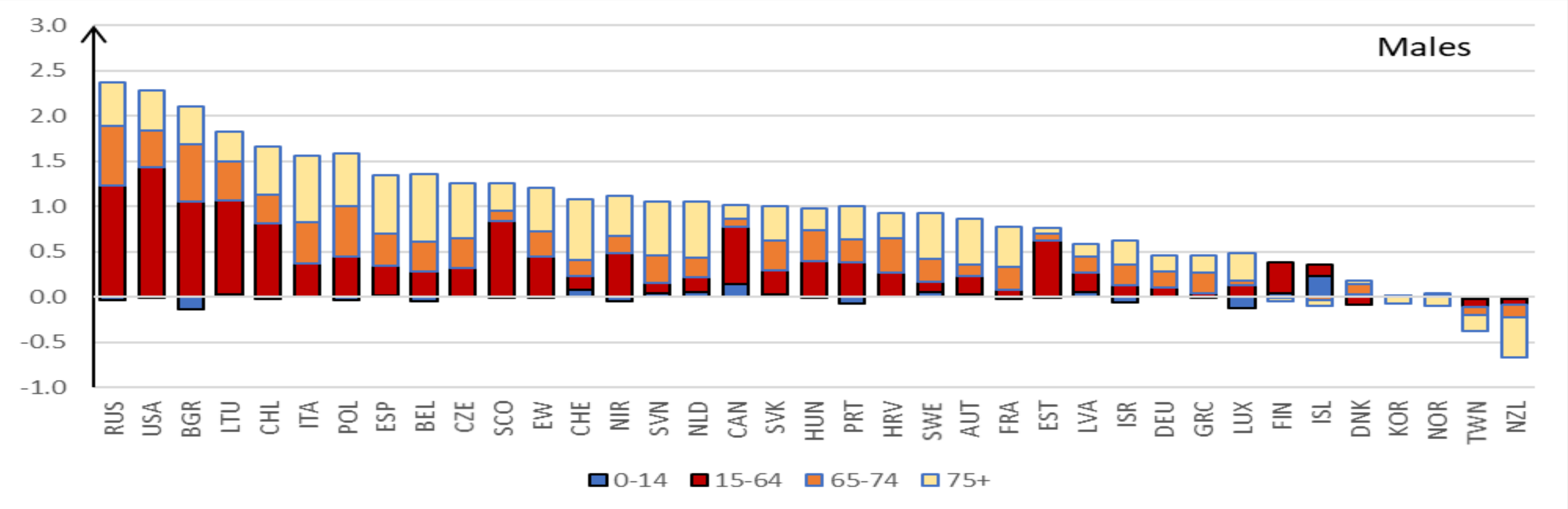
# ESDR among men and women and the gender gap



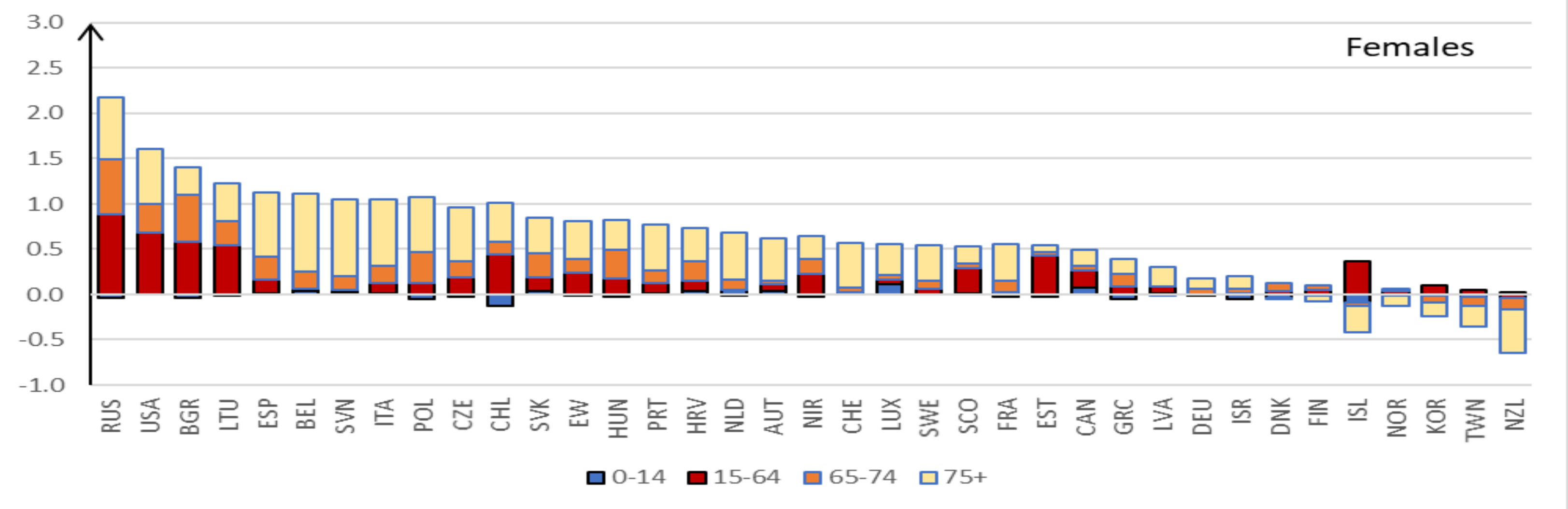

| | M-F Diff. per 100 000 | M/F ratio |
|---|---|---|
| Mean | 61.9 | 1.9 |
| Median | 59.4 | 1.9 |
| Q1 | 35.4 | 1.6 |
| Q3 | 74.6 | 2.3 |

SDR-excess.xlsx/ESDRabs. Data: SDR-ESDR-aggr-ages-2020.dta. ESDR-SDR-scatter.do; SDR-obs-exp-2020.R

# Life expectancy losses and their age components




| | Total | % 15-64 | LE |
|---|---|---|---|
| Mean | 0.914 | 29.20 | 78.08 |
| Median | 0.969 | 26.59 | 79.30 |
| Q1 | 0.459 | 15.70 | 76.57 |
| Q3 | 1.254 | 47.24 | 80.35 |



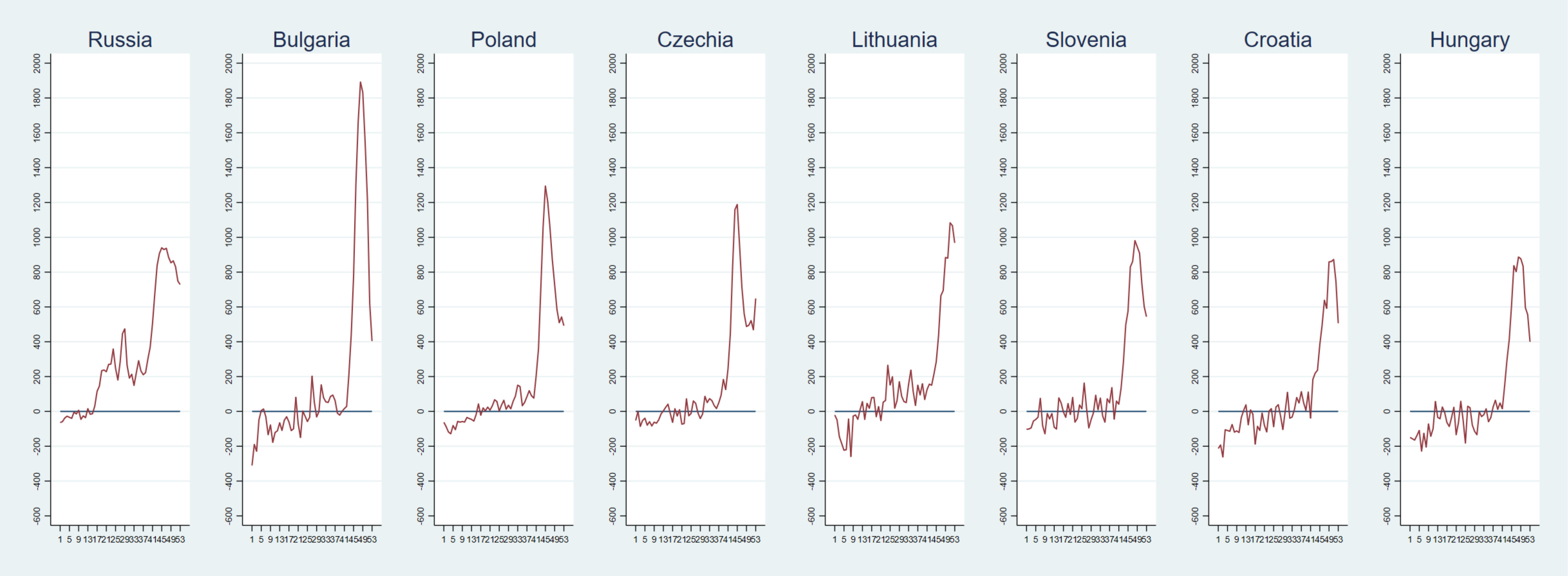

| | Total | % 15-64 | LE |
|---|---|---|---|
| Mean | 0.622 | 29.14 | 83.36 |
| Median | 0.620 | 20.00 | 83.94 |
| Q1 | 0.301 | 11.56 | 81.90 |
| Q3 | 0.939 | 40.60 | 84.75 |

Mortality measure = LE,
Method = Lee-Carter projection,
Metrics = $LE_{baseline} - LE_{obs}$
Ref period = 2005-2019

LE-age-components.xlsx. Data: Decomp_Aggr-e0_exp-obs-2020.csv

# Excess mortality trajectory

# ESDR by week in 2020 for both sexes: East

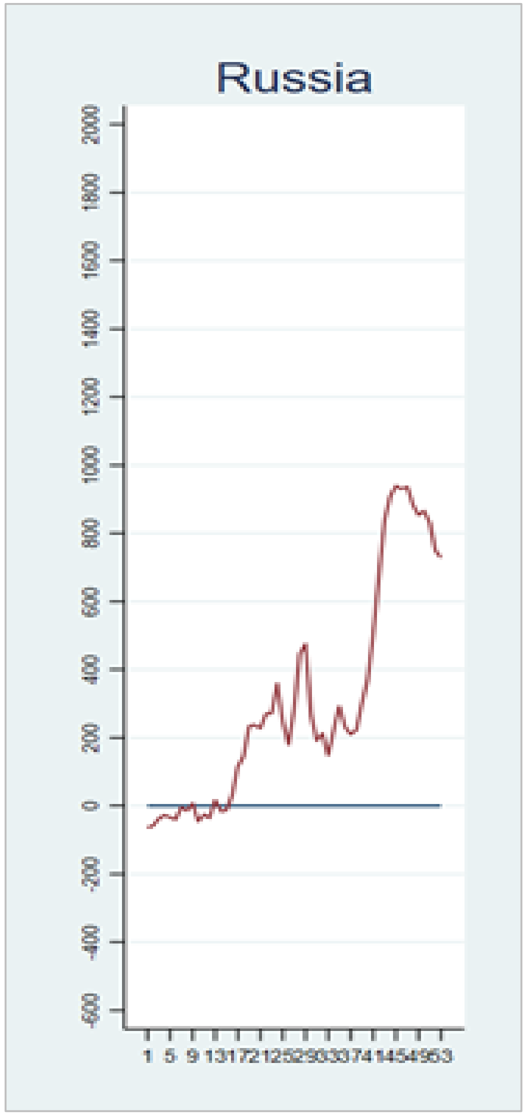


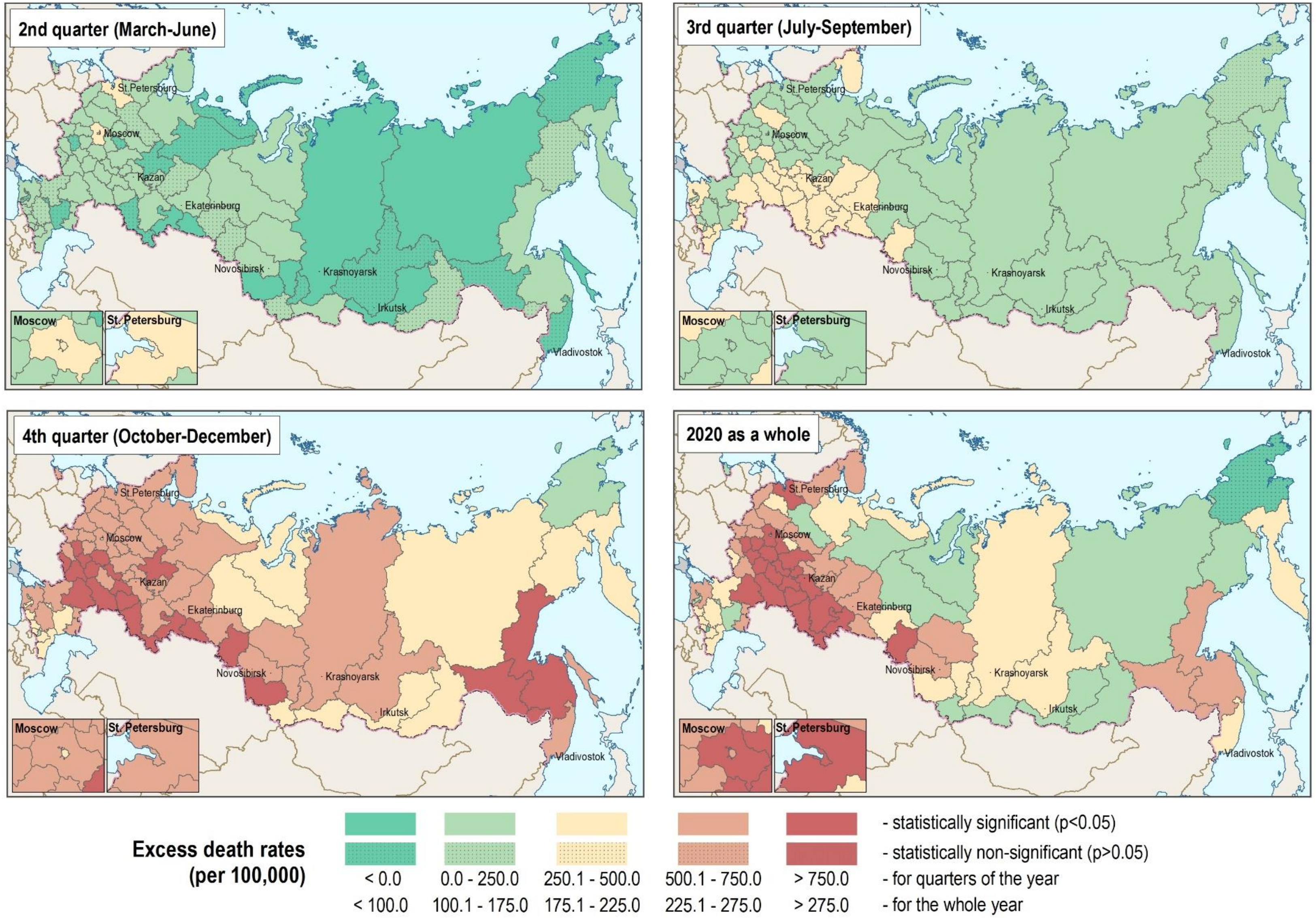

x_G1-x_G20. png. ESDR-Figures-build-weekly.do. weekly_dataset_abr.csv

# ESDR by week in 2020 for both sexes: West


x_G1-x_G20. png.
ESDR-Figures-build-weekly.do.
weekly_dataset_abr.csv

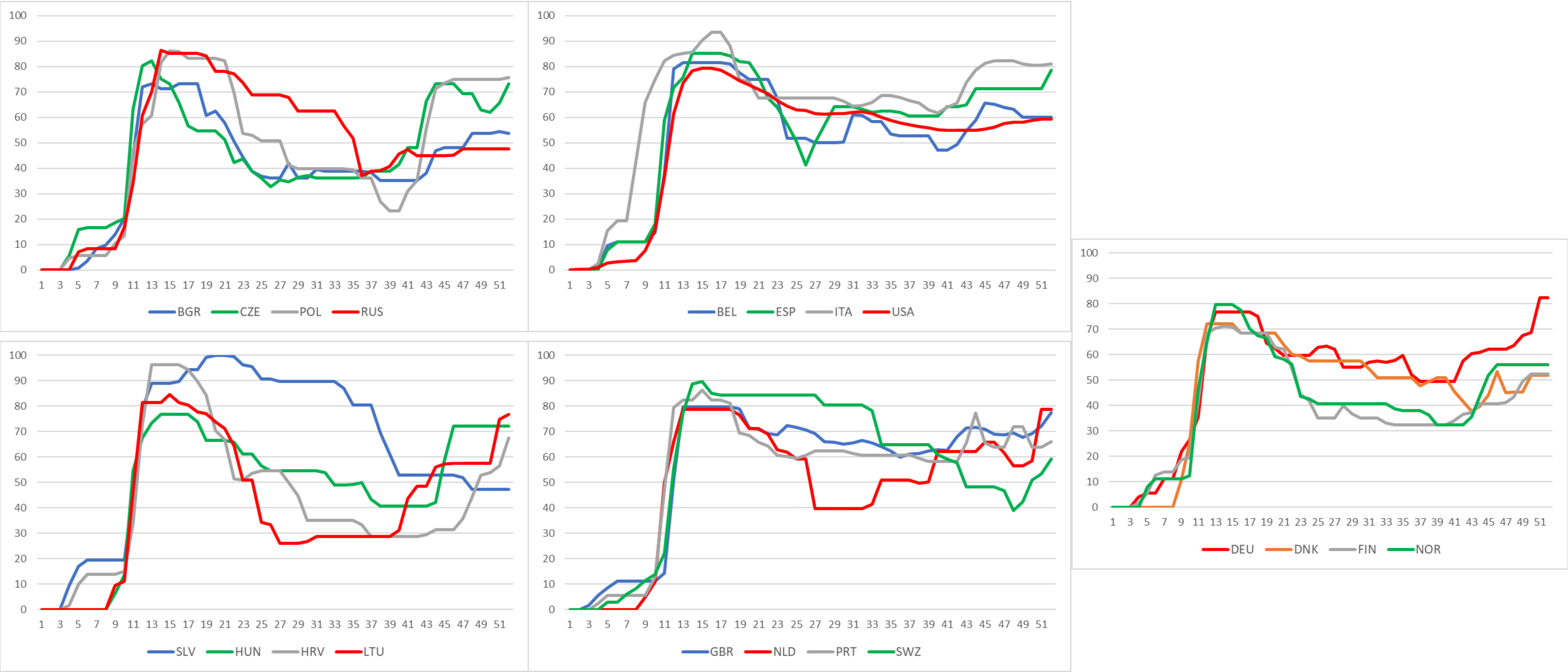
# Geographic spread of excess mortality across Russia in 2020




Source: Timonin et al. Excess mortality in Russia and its regions compared to high income countries: an analysis of monthly series of 2020. SSM-Population Health (In press).

# Stringency index by week of 2020




Source: Stringency index values by week of 2020 downloaded from
https://github.com/OxCGRT/covid-policy-tracker/blob/master/data/OxCGRT_latest.csv

Stringency.xlsx . Stringency-weekly.do . OxCGRT_latest.csv.

# Summary

- Excess mortality is the gold standard method for estimation of mortality impacts of the COVID-19 pandemic irrespective of well-known problems with SARS-CoV-2 testing and its registration as the main cause of death.
- Quantitative estimates of excess mortality and lifetime losses depend on the choice of mortality measure, method of calculation of the baseline mortality (incl. accounting or not accounting for the annual trend), length of the reference period, and time units. Scholars and policymakers interpreting the results should understand sense of the mortality measures and underlying assumptions.
- In this presentation, we reported excess age-standardized death rates (ESDRs) in 37 developed countries in 2020 as the difference between the baseline weekly SDRs calculated from the weekly death rates in 2005-19 using the *Average+Trend* method and the observed weekly SDRs.
- The highest ESDRs for both sexes were found in Russia, Bulgaria, Poland, Czechia, Lithuania, the USA, Slovenia, Belgium, Italy, and Croatia. New Zealand, Taiwan, South Korea, and Scandinavian countries experienced no mortality excess. In countries with non-negative ESDRs, the mean ESDR constituted 10% of the baseline SDR with the lower and the upper quartiles 6.4% and 14.5%, respectively.
- Male ESDRs were 1.9-fold higher than the female ones on average with the largest absolute gender gaps being the highest in Bulgaria, Russia, Poland, and some other Eastern European countries.

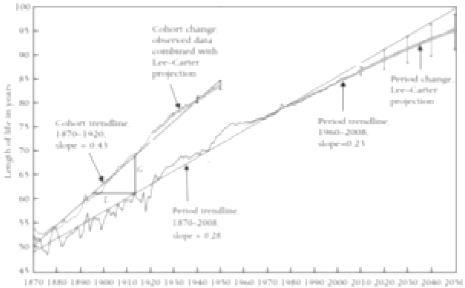
# Summary (2)

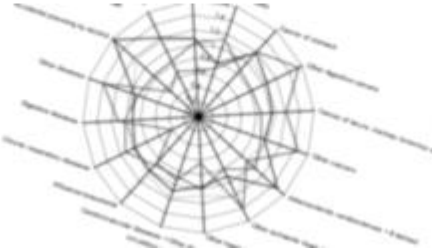
- To estimate life expectancy losses, we subtracted the observed LE values from the baseline LE values calculated from (Lee-Carter-forecasted) age-specific death rates with 2005-19 as the reference period.
- The mean LE losses were 0.9 years for men and 0.6 years for women. The lower and upper quartiles were equal to 0.5 and 1.3 years for men and 0.3 and 0.9 years for women.
- The largest LE losses were observed in Russia and the USA. High LE losses were seen also in Bulgaria, Lithuania, Poland, Italy, Spain, Czechia, and Belgium. In the USA, excess mortality at ages 15 to 64 produced almost 60% of LE losses among males and almost 50% of LE losses among females. In Bulgaria, Russia, Lithuania, Scotland, Chile (males only), and Canada the share of ages below 65 in the total life expectancy losses was also surprisingly high. New Zealand, Taiwan, Norway, and South Korea did not experience LE losses.
- While in Belgium, Italy, Spain, and parts of the UK, major mortality peaks were observed in Spring 2020, in Eastern European countries the mortality excess was concentrated on the last 10 weeks of the year. Russia and the USA faced ESDR peaks in both April-May and November-December.
  In these two countries with large and heterogeneous territories, mortality excess was observed during most of 2020 possibly due to different schedule of the pandemic in different parts of these countries.

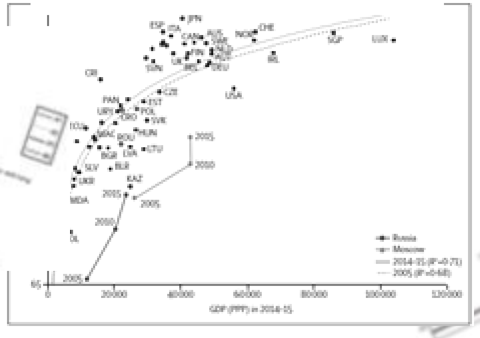
# Спасибо за внимание !

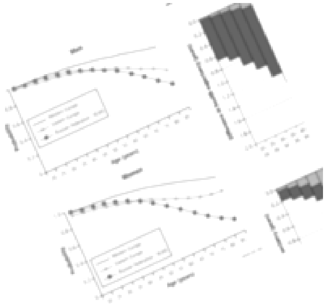
$$AID_t = \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\left|SDR_{t,i} - SDR_{t,j}\right|p_{t,i}p_{t,j}$$

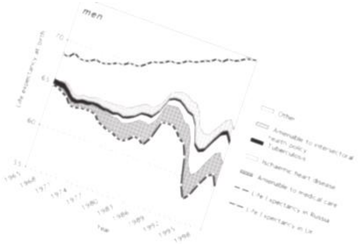
$$e^{\dagger} = e_0^{\dagger} = \sum_{y=0}^{\omega-1} d_y e_{y+1} + \left(1 - \sum_{y=x}^{\omega-1} d_y a_y\right)$$

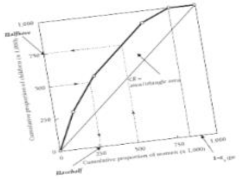


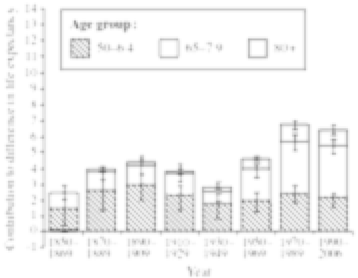


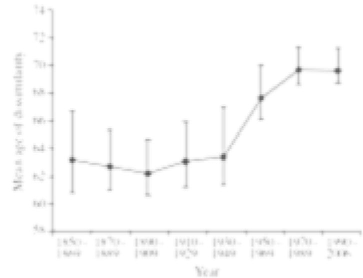








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# Additional

# Need for data on all-cause mortality by week, age, and sex

**Correspondence**

**COVID-19: a need fo**
**real-time monitorin**
**weekly excess death**

The first-line epidemio
response to coronavirus diseas
(COVID-19) requires estimatio
parameters, including case fata

We therefore urge all national authorities who can collate counts of weekly deaths to expedite the publication of these data and place them in the public domain. The dissemination of this information should be done within 3–4 weeks of the period of observation. At a minimum, tabulations by sex and 5-year age groups are essential.

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S0140-6736(20)30933-8

Source : Leon DA, Shkolnikov VM, Smeeth L, Magnus P, Pechholdová M, Jarvis CI. COVID-19: a need for real-time monitoring of weekly excess deaths. The Lancet 2020.