

**Epidemiological bulletin**

**17th** | 2020

Online in advance: April 9, 2020

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**Estimation of the current development of the SARS-CoV-2 epidemic in Germany - nowcasting**

**Explanation of the data used** There is great interest in presenting and understanding the current infection situation and the timely development of SARS-CoV-2 infections and Covid-19 cases in Germany. Naturally, no one can exactly know or determine the actual number of infections that occurred today or in the past week. Only when the people concerned have been tested positively can their number be recorded and analyzed in a survey system. In general, however, it is true that not all infected people develop symptoms, not all who develop symptoms go to a doctor's office, not all who go to the doctor are tested and not all who test positive are also recorded in a survey system. In addition, there is a certain amount of time between all these individual steps

In Germany, doctors and laboratories report infections with SARS-CoV-2 to the responsible health authorities in accordance with the notification obligation under the Infection Protection Act (IfSG) and from these to the competent state authorities to the [Robert Koch Institute (RKI)](https://www.rki.de/DE/Home/homepage_node.html) transmitted.

To the current data status (8.4.2020, 00:00 a.m.) there were 103,140 SARS-CoV-2 cases. Among them were 50,761 (49.8%) men and 51,988 (50.0%) women. In 391 (0.2%) other cases, the sex was either diverse, not assessed or not known. The median age was 50 years (interquartile range [IQR]: 33 - 61 years), 207 cases had no age information. If the cases are entered after the date of receipt at the RKI, the curves in Figure 1 result. Up to 6,000 cases per day have been sent to the RKI by the health authorities, somewhat less in the past few days Development by gender and age group shows above all a clearly increasing number of new ones

Cases of illness in the age group (80+).

**Number of new SARS-CoV-2 cases**

6,000

4,000

2,000

0

**Date of receipt at the RKI**

**Fig. 1 |** Development of the number of new SARS-CoV-2 cases in Germany after the date of transmission to the RKI. The dashed vertical lines mark the start of the measures listed in Tab. 1 (p. 15) on March 9,

March 16 and March 23, 2020.



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The cases reported to the RKI by the health authorities on a daily basis do not directly reflect the current infection, as stated above. The chronological course of the current infection would best be represented by the number of infections that occurred daily. In most cases, however, the exact time of infection is not known or cannot be determined.

The report to the RKI shows that 50% of the cases were transmitted after 7 days. In most cases, this duration is between 5 and 10 days. An analysis of the temporal dynamics of this distribution after the day of receipt at the RKI showed: The average rose between March 12 and 21 from 5.3 days to 6.6 days. Between March 22 and 28 it was about 8 days, between March 29 and 31 it was about 9 days. Since April 1, the duration from the onset of illness to the submission of the report to the RKI has been decreasing again and was recently around 8 days. These shifts are reflected in the imputation of the missing values ​​of the

The beginning of the disease is taken into account.

**Imputation of missing values ​​at Onset of illness**

In order to present the current development of the SARS-CoV-2 epidemic, the date of illness (date of symptom onset) is the most suitable parameter available from the reported data. The onset of the disease was indicated by the health offices in 62,909 (61%) cases. In some cases of confirmed SARS-CoV-2 infection, an asymptomatic course develops, so that the onset of the disease never occurs. Nevertheless, these cases are also assigned an artificial onset of disease in the context of our analysis, they are treated as if the start of the disease was not specified. InIn 511 cases, the time interval between the date of transmission to the RKI and the onset of the disease was negative or was more than 30 days \*. These cases were not included in the subsequent analysis and imputation of the onset of the disease.

To The implementation of the multiple imputation (separated by gender and age group) was assigned to 200 realizations from the empirical distribution of the duration between the onset of illness and the date of transmission to the cases without onset of the illness. The difference between the transmission date and this distance then gives the different realizations of the simulated onset of the disease. This gives us an estimate of the onset of the disease in the cases already transmitted (see Fig. 2 "Onset of the disease imputed", p. 12).

**Explanation of the nowcasting**

Nowcasting **2nd** creates an estimate of the history the number of SARS-CoV-2 disease cases that have already occurred in Germany, taking into account the delay in diagnosis, reporting and transmission. To do this, we determine the proportion of cases reported after a certain number of days, x, after the onset of the disease. This percentage is used to correct the number of reported reports with the onset of illness x days before the status of the analysis. It should be noted that only recently diagnosed, reporting and transmission intervals have been recorded for recently ill cases.**3rd**

A so-called multiple imputation was carried out as a procedure for replacing this missing information.**1** in which the missing data values ​​are estimated on the basis of the statistical relationships of the known data. The date of receipt of the case report at the RKI was used as the most important information for determining the missing onset of the disease. The missing values ​​were estimated separately according to gender and age group.

The distribution of the duration between the onset of the disease and the date of submission of the notification

In the current procedure we make the simplifying assumption that the correction is constant over time. An evaluation of this assumption shows that the estimated distribution of the share over time leads to a more complete transmission

\*Note: A duration of 0 days or even a small negative duration can be explained by cases that were tested as part of a contact person follow-up of a confirmed case and only developed symptoms after the positive test.



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Cases:

ErkrBeginn indicated ErkrBeginn imputed Nowcast

95% PI

95% PI

**Number of new cases**

10,000

8,000

6,000

4,000

2,000

0

**Date of onset of illness**

**Fig. 2 |** Estimated development of the number of new SARS-CoV-2 cases in Germany (nowcast) due to the partially imputed date of onset of the disease and adjusted for diagnosis and reporting delay with 95% prediction intervals (95% PI).

The dashed vertical lines mark the start of certain measures on March 9, March 16 and March 23, see Tab. 1 (p. 15).Shown until April 4th; 3 days before the analysis.

developed after a given number of days. Therefore, nowcasting tends to slightly overestimate the expected number of cases.

small part of these cases is recorded. Overall, nowcasting tends to be relatively sensitive to fluctuations in the number of new cases in the vicinity of the status of the evaluation, but stabilizes after a few days if the increase or decrease is not confirmed (see Fig. 3, P. 13).

**Nowcasting results**

The course of the curve of the cases transmitted to the RKI (gray and dark blue), especially in the last 10 days, is significantly below the estimated course of the already symptomatic cases (light blue) in Germany, which had an onset of disease a few days ago and only a small one Parts were diagnosed, reported and transmitted (see Fig. 2). The course of the expected new cases, corrected for the delay in reporting and submission, initially rises steadily, but stabilizes at a level of around March 16

5,000 new cases a day. Since March 30, this number may have increased to over 6,000 new cases per day (see Fig. 2).

A look at the development by gender and age groups (0 - 19, 20 - 39, 40 - 59, 60 - 79 and 80+) shows that the forecast number of cases per 100,000 inhabitants in the age group (80+) increases particularly sharply. This will presumably also be seen in a stronger increase in the number of hospitalized cases and cases requiring intensive care. In absolute numbers, the adults dominate between the ages of 20 and 79, due to the high proportion of the total population, especially the 40 to 59 year olds.

**Estimation of the reproduction number R** Based on the nowcasting, an estimate of the time-dependent reproduction number R can be carried out. The number of reproductions is the number of people who are infected by an index case on average. Based on the current state of knowledge, we assume that an average of 5 days pass between the infection and the onset of the first symptoms. Are probably infected

The 95% prediction intervals show the uncertainty due to the adjustment after the delay in diagnosis and reporting as well as due to the missing information at the beginning of the disease. Nowcasting is unstable for cases with an onset of disease 3 days or less before the status of the analysis, since within 3 days one to



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Stand Nowcast:

27.03.

28/03

27.03.

28/03

29.03.

3/30

29.03.

3/30

March 31

April 1

March 31

April 1

April 2

April 3

April 2

April 3

04/04

04/05

04/04

04/05

April 6

April 7

April 6

April 7

Status reports:

10,000

8,000

6,000

4,000

2,000

0

**Date of onset of illness**

**Fig. 3 |** Comparison of the estimated development of the number of SARS-CoV-2 cases in Germany (nowcast) to different data levels, the current estimate with prediction interval. The dashed vertical lines mark the startof the measures on March 9, March 16 and March 23, see Tab. 1 (p. 15).

However, people become infectious about 2 days before the onset of symptoms and can therefore infect other people as early as 3 days after their own exposure. The generation time describes the average time span from the infection of a person to the infection of the subsequent cases infected by him. We estimate this period of time to be about 4 days because the infectivity is particularly high at the beginning of the infection and the infected person is not aware before the onset of symptoms that he can already infect others. The generation time is not a stable characteristic of the pathogen, but, like the number of reproductions, depends on various factors and can change over time.

catch the infection happen.

confirmed to appreciate new SARS CoV-2 diseases.

With a constant generation time of 4 days, R is the quotient of the number of new illnesses in two successive time segments of 4 days each. If the number of new illnesses increased in the second period, the R is above 1. If the number of new diseases is the same in both periods, the number of reproductions is 1. This corresponds to a linear increase in the number of cases. If, on the other hand, only every second case infects another person, ie R = 0.5, then the number of new infections halves within the generation period.

The R estimate for the beginning of March shows values ​​in the range of R = 3, which then decrease and have stabilized around R = 1 since March 22 (see Fig. 4, p. 14). R has risen again slightly since around March 30 and stands at 1.2 on April 4 (95% PI: 0.9 - 1.6). One possible reason for the slight increase is that the virus is now spreading more widely among older people as we are also increasingly seeing outbreaks in nursing homes and hospitals. Another aspect, however, is that test capacities in Germany have been significantly increased and a larger proportion of infections are visible as a result of stronger testing

If each case infects 2 follow-up cases on average (R = 2), then the number of new infections doubles after each generation. In contrast, the number of new infections is halved with a reproductive number R = 0.5. It is precisely this dynamic that can be used in reverse to determine the effective number of reproductions from the

**Number of new cases**

R

ion number

Reproductive

ive

ect ff

E

date

alls

if applicable F

number A

lere t

With

3.5

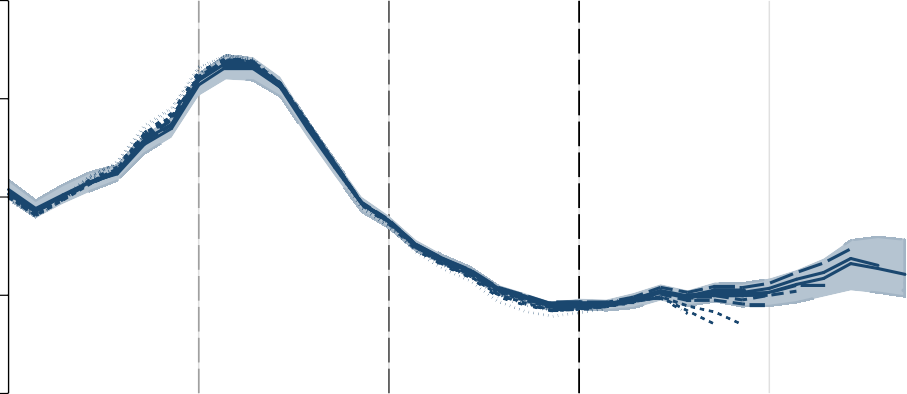
2.5

1.5

1

2nd

3rd



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Number of reproductions

95% PI

3.5

3rd

2.5

2nd

1.5

1

**date**

**Fig. 4 |** Estimation of the effective reproduction number R for an assumed generation time of 4 days. The dashed vertical lines indicate the start of the measures listed in Table 1 (p. 15) on March 9, March 16 and March 23, 2020.

becomes. This structural effect and the resulting increase in the number of reports can lead to the current R-value somewhat overestimating real events. Adjustment for the higher test rates is not possible without further ado because there is no sufficiently differentiated test data.

Here, too, individual small outliers that disappear after a few days.

In the figures for the Nowcast and the R estimate, the date of the start of important measures to contain the SARS-CoV-2 epidemic in Germany is shown for orientation. However, these times are not included in the estimate of the nowcast itself. In addition to the testing of suspected cases, the isolation of confirmed cases

A stability analysis of the R estimate shows that the R value behaves overall more stable than the Nowcasting itself (see Fig. 5). Still find yourself

Data status:

27.03.

28/03

29.03.

3/30

March 31

April 1

April 2

April 3

04/04

04/05

April 6

April 7

4th

3rd

2nd

1

0

**Date of onset of illness**

**Fig. 5 |** Comparison of the estimate of the effective reproduction number R for an assumed generation time of 4 days for different data levels. The dashed vertical lines mark the start of those mentioned in Tab. 1 (p. 15)Measures on March 9, March 16 and March 23, 2020.

**Average number of follow-up cases**

**Effective reproduction number R**



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and the quarantine of close contacts in confirmed cases, these are general contact-reducing measures to reduce the spread of the virus (see Table 1).

An R estimate is also possible based on the course of the new cases, for example after the reporting date, and this is often the only option for international data. In principle, this should lead to similar results, but should be somewhat more susceptible to reporting artifacts.

**Tab. 1 |** Start measures to contain the SARS-CoV-2 epidemic in Germany, 2020.

**literature**

**1** Little RJ, Rubin DB: Statistical analysis with missing data: John Wiley & Sons; 2019

**3rd** Lawless J: Adjustments for reporting delays and the prediction of occurred but not reported events. Canadian Journal of Statistics 1994; 22 (1): 15-31

**2nd** Höhle M, an der Heiden M: Bayesian nowcasting during the STEC O104: H4 outbreak in Germany, 2011. Biometrics 2014; 70 (4): 993 - 1002

**author**

**a)** Dr. Matthias an der Heiden | **b)** Dr. Osamah Hamouda

**a)** Robert Koch Institute | Department 3 | FG 34 HIV / AIDS and other sexually transmitted or blood-borne infections

**b)** Robert Koch Institute | Department 3

**Conflict of interest**

The authors state that there is no conflict of interest consists.

**Correspondence:** [a](mailto:anderHeidenM@rki.de)[nderHeidenM@rki.de](mailto:nderHeidenM@rki.de)

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**Start of the measure**

**measure**

9th March

Cancellation of large events in different federal states (with more than 1,000 participants)

March 16

Federal-state agreement on guidelines against the spread of the coronavirus

March 23

Nationwide extensive ban on contacts