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Assessment of the infection dynamics and the disease burden of COVID-19 in Germany

Einschätzung von Infektionsdynamik und Krankheitslast von COVID-19 in Deutschland

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Abstract: The last months of the COVID-19 pandemic have shown that implementing informative indicators for infection dynamics, assessing direct and indirect burden of disease and communicating uncertainties of predictions clearly to stakeholders and the public are crucial elements in the pandemic response. To achieve these aims, coordination within the scientific community is crucial to avoid duplication of work and ensure rapid availability of needed models, estimations, and epidemiological studies.

Keywords: COVID-19; excess mortality; infection dynamic indicators; pandemic preparedness; uncertainty of forecasts.

Zusammenfassung: Die letzten Monate der COVID-19-Pandemie haben gezeigt, dass die Implementierung informativer Indikatoren für die Infektionsdynamik, die Bewertung der direkten und indirekten Krankheitslast und die eindeutige Kommunikation von Unsicherheiten in Bezug auf Vorhersagen an die Interessengruppen und die Öffentlichkeit entscheidende Elemente der Pandemie-Reaktion sind. Um diese Ziele zu erreichen, ist die Koordination innerhalb der wissenschaftlichen Gemeinschaft von entscheidender Bedeutung, um Duplizierung von wissenschaftlicher Arbeit zu vermeiden und die rasche Verfügbarkeit der erforderlichen Modelle, Schätzungen und epidemiologischen Studien sicherzustellen.

Schlüsselwörter: COVID-19; dynamische Infektionsindikatoren; Pandemievorsorge; Übersterblichkeit; Unsicherheit der Prognosen.

Using available and building future indicators to assess infection dynamics

One of the major contributions public health can make during a pandemic is the quantitative prediction and timely measurement of infection dynamics and disease burden and the establishment of indicators to this end [1].

Numerous informative indicators of infection dynamics and disease burden are available and were built up during the pandemic in Germany. These include testing frequency and number of positive tests over number of tests performed, how high the positivity risk of these tests is [2], how the reproductive number is developing [3, 4], how many ICU beds are available [5], how many people are currently suffering from respiratory symptoms (AGI), which viruses cause respiratory infections [6] and whether there was excess mortality 4-8 weeks ago [7].

These indicators need have been supplemented by continuous population-based especially seroprevalence studies, indicating low seroprevalences mostly and an expected to observed ratio of 2–8 in Germany as well as infection fatality estimates of 0.5–1.5% [8, 9]. Another potential useful indicator is the expansion of the already existing sentinel surveillance. The number of samples received currently is rather low and an expansion would lead to more stable and detailed results than current notification systems with changing test strategies can provide [6]. A rather novel method – although well-known from other infectious diseases – would be monitoring viral loads in wastewater as an indicator of otherwise unnoticed outbreaks for example in younger population groups [10]. And while we now have a fairly good overview of the utilization of clinical facilities via both the German Society for Intensive Care Medicine (DIVI) and the AKTIN-register (Verbesserung der Versorgungsforschung in der Akutmedizin in Deutschland durch den Aufbau eines Nationalen Notaufnahmeregisters) data [5], we do not know the same for the utilization of public health agencies capacities. Developing similar indicators for health authority

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capacity would be essential. For that, regional and super-regional reporting of indicators such as the number of positive contacts per index case found could be implemented. Excess mortality is another indicator that could be further developed and used. In Germany, the Federal Statistical Office very quickly presented figures on mortality this year [7], and several analyses show that the excess mortality in Germany was low, whereas in other countries, more severely affected by the epidemic during February to July, it was high [11]. What is not possible currently – but important in the future – is to assess cause specific excess mortality. This is due to a lack of time sensitive data on causes of death in most countries. Assessing cause-specific excess mortality would allow to assess direct and indirect regional effects of the pandemic more clearly and in (nearly) real-time.

Including direct and indirect components of disease burden in estimations

The disease burden during a pandemic – whether expressed as mortality, years of life lost or frequency of disease – is ultimately composed of direct and indirect burden of disease (Figure 1) caused both by the pandemic and measures against the pandemic.

Disease burden directly caused by SARS-CoV-2 is composed of patients who die from COVID-19, fall ill, or have long-term consequences. The most important variable to influence disease burden of persons infected with SARS-CoV-2 is age. This means that crude case fatality estimates depends fundamentally on the population – in particular age – structure of infected persons, the varying degree of under-reporting of both cases and deaths, a time lag between reporting and death, and the capacity of the health care system in the country treating the disease [12]. While most evidence agrees that advancing age is the single most

important risk factor for a severe course of COVID-19, the role of age as an effect modifier of the association of other risk factors such as predisposing conditions and severity of disease is not yet clear [13]. This interaction is important to consider in the design of future non-pharmaceutical strategies as well as vaccination strategies.

Indirect disease burden includes health effects of both the pandemic and the measures taken against the pandemic. These include COVID and non-COVID patients not being treated properly due to health care systems being overburdened [14] and additional burden of disease arises due to underuse of the health care system as patients with chronic conditions no longer want to or are unable to access health care [15]. Furthermore, economic consequences of the pandemic as well as pandemic measures also have health consequences. Positive indirect effects on disease burden of those conditions associated with air pollution [16] and infectious diseases with similar transmission pathways to SARS-CoV-2 such as influenza [17] have been reported.

At the beginning of the pandemic there was little to no evidence for any of the indirect effects of the pandemic. This has now changed and current pandemic measures are aiming at mitigating any of the adverse indirect effects by considering the available evidence [18].

Towards even further coordinated networks of scientists

In March, first simple SIR models were built for the city of Brunswick (Figure 2) and then more sophisticated infectious disease modelling was implemented [3]. In other cities of Germany similar models were created [19] and similarly found that, given the assumed parameters, it was quite possible that intensive care capacities would be exceeded within a few weeks, accompanied by high mortality rates. International quantitative modelling

Figure 1: Disease burden during the SARS-CoV-2 pandemic (Own illustration).

Figure 2: The initial “good case” scenario calculated with parameters available in March 2020 and informing ranges of potentially needed hospital beds in Brunswick, Germany based on a very simple SIR model on 15.03.20 (personal archive): R_t initially 2.4, after 4 weeks reduction to 0.9 (Own illustration).

confirmed this and clearly showed that simple containment, without strong measures, was unlikely [20].

So, interestingly, in many cities and regions over Germany similar quick and rapid simulation studies were built up on remarkably similar issues to give rapid assessments. While all individual local models were important, quick, and efficient coordination might have helped early on to integrate the simulation studies available more efficiently with the most important questions infectious disease epidemiologist, official stakeholders and the public were asking. Similarly, it would have been important to integrate the – simultaneously ongoing – evidence synthesis efforts into the modelling platforms and for both to inform each other early on. Several coordination initiatives like this were quickly built up in March, including one led by dgepi (https://www.gmds.de/fileadmin/user_upload/aktuelles-terminen/200325_RKI.pdf). However, ideally of course these would have existed in advance and would have provided data from January onwards [21].

Declaring aims and uncertainties in predicting infection dynamics

Simulation studies at this point in time are a representation of the extremes and scenarios more than a detailed

forecast of what will happen. It is therefore particularly important at this point in time to explain the usefulness and – non-usefulness of these models very well to political stakeholders and the public and follow simple communication guidelines to this end [22].

Forecasts in the future might consider including parameters such as seroprevalence and thus possible unreported cases, syndrome surveillance, mobility data and possibly even sewage data at the regional level. Forecasts should also aim at providing age specific estimates for COVID-19 where age specificity of exposure, infection, symptomatic and severe course of disease is of paramount importance. Contact structures and contact fields of the population might help if the current contact surveys and matrices are available. Even if developing forecasts to this level however, uncertainties will always persist in any forecast predicting infection dynamics for the next few weeks. Research groups generating these forecasts should consider to communicate aims, limits, and uncertainties carefully, clearly, and transparently, as well as towards stakeholders and towards the public.

Ideally, future forecasts include age-specific estimations and expected indirect as well as direct disease burden based on expected infection dynamics and known consequences of measures to inform regional and super-regional pandemic management.

Conclusion

In conclusion, implementing indicators for the utilization and capacity of the public health agencies as well as real time cause-specific excess mortality estimates are essential to implement and coordination within the scientific community is crucial to avoid duplication of work and ensure rapid availability of needed models, estimations, and epidemiological studies. Future prediction models will benefit from including age-specific estimates, known contact structures of the population and measures of direct and indirect burden of disease to inform regional and supraregional pandemic management.

Author Declaration

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