The Bed Forecast

Data models calculate intensive care bed requirements for the next two weeks

By Andreas Lorenz-Meyer

Since March, regional forecasting models have been predicting intensive care bed occupancy in Hessen's hospitals. This eases the work of those responsible on the ground. And it helps to keep the health system stable – in the current crisis as well as in future ones.

The scenes in Bergamo in Northern Italy back in the spring of 2020 were haunting: A convoy of military trucks transported people who had died of COVID-19 to the crematoria. Today, 15 months later, Bergamo still serves as a cautionary example: Health systems must not be allowed to collapse. To prevent this happening in Germany, the University Medicine Network has launched the egePan Unimed project. All German university hospitals belong to this network, in the framework of which they aim to pool data, research results, action plans as well as diagnostic and treatment strategies in order to better combat the virus. The egePan Unimed project is one of a total of 13 inter-hospital projects within the network. The objective: optimal, regionally adapted pandemic management. 26 university hospitals and external research institutes are taking part in a total of eight work packages. Work Package 2, in short WP2, comprises the forecasting models. These mathematical models use current incidence figures to forecast intensive care bed occupancy in

a specific region over a period of one to two weeks. How many people there will contract COVID-19? And how many of them will be intensive care patients?

How long do patients remain in the intensive care unit?

Since March 2021, the models have been forecasting bed occupancy in Hessen in relation to the federal state as a whole and the six individual catchment areas. The Executive Department for Medical IT Systems and Digitalisation at University Hospital Frankfurt is responsible for compiling the overall analysis and distributing the forecasts. Michael von Wagner, the department's director, explains why the forecasts are so complicated: "Forecasting models work with assumptions about the future. It's inevitable that these are going to deviate to a greater or lesser degree from what then actually happens in reality." This is because unknown variables always come into play in such assumptions. For example, length of stay. Do patients stay an average of five days in the ICU? Or eight days? Since complications might arise, nobody can say for sure: The patient with weak kidneys suddenly requires dialysis and therefore stays longer – the average promptly increases. The occupancy rate itself is also one of the incalculable factors. If the occupancy rate is 60 per cent, patients are often given a day or two more in order to be on the safe side. Things are different when an ICU is working at the limit – like in Frankfurt around Christmas 2020, when patients even had to be transferred to the north of Hessen. "In such a tense situation, we're no longer so generous when it comes to prolonging stays," says von Wagner. The outcome: The average length of stay shortens.

Computer models from weather forecasting

In order to tackle the problem of these unknown variables, ensemble models are brought into play, like the ones meteorologists also use for their weather forecasts. Here, the results of several forecasting models, each with its own assumptions, are merged into one overall result. In the case of the WP2 forecasts, the university hospitals in Dresden, Augsburg, Münster and Göttingen as well as the Helmholtz Centre for Infection Research in Braunschweig form the ensemble. IT groups are working there on their own models, feeding them with Hessen's current incidence figures, adding their own assumptions and on this basis calculating a forecast for each catchment area, with information on the number of occupied beds on normal wards and in ICUs. In the next step, the five individual forecasts are forwarded to the team at University Hospital Frankfurt, which calculates the mean value with standard deviation. "The ensemble model ensures that the forecasts are reliable," says von Wagner: "It levels out the deviations of the individual models and in this way assumptions and reality align more closely."

Intensive care bed occupancy in Offenbach

Anaesthetist Haitham Mutlak, senior consultant at Sana Klinikum Offenbach and a member of its crisis task force, can endorse this. Each Fri-

IN A NUTSHELL

- Having enough intensive care beds for COVID-19 patients was a major concern during the pandemic.

- Mathematical models were developed within the University Medicine Network to forecast intensive care bed occupancy for two weeks.

- The models should help to keep the health system stable during future epidemics too.

ABOUT MICHAEL VON WAGNER

Michael von Wagner, 49, has been medical director of the Medical Information Systems and Digitalisation Unit and Chief Medical Informatics Officer at University Hospital Frankfurt since 2019. He was previously medical director of the Central Patient Management Unit and senior consultant for gastroenterology at Medical Clinic 1. Von Wagner studied medicine at Goethe University from 1993 to 2000 and earned his doctorate in 2002. His scientific work has included, among others, the in vivo dynamics of the hepatitis C virus and treatment of chronic hepatitis C.
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day, he receives the 7-day forecast for the Federal State of Hessen and for Catchment Area 4 (Frankfurt-Offenbach). With these data, he can "optimally" control intensive care bed occupancy for the following week because the forecasts are "wonderfully accurate". This could already be seen shortly after the forecasts started. In mid-March, when the number of infections rose significantly as a result of the Alpha variant, the forecast was: The number of COVID-19 inpatients is increasing, but the number of intensive care patients is more or less constant. And that is what indeed really happened: In Catchment Area 4, only marginally more COVID-19 patients had to go into intensive care than before.

> *"The forecasts for intensive care beds are wonderfully accurate."*
>
> Dr Haitham Mutlak,
> Sana Klinikum Offenbach

Back then in March, the reason for this was, among others, that most over-80s had already been immunised and were thus protected from suffering a severe progression of the disease. Although there were indeed more infections in the still unvaccinated age group below, that is, the over-50s, "these were cases with a milder progression that needed intensive care far less often," says Mutlak. The regional forecasts ease the intensive care physician's work no end. If he knows that the situation in the following week will remain more or less the same, he can allocate available capacities to the various departments "in a fair and transparent way". On the Monday, for example, general surgery is assigned a place for the tumour patient following her operation, on the Tuesday a bed is reserved for neurosurgery, and so forth. In Mutlak's view, there are two reasons why the forecasts are reliable.

Firstly, the forecasting models work with regional incidence figures and not with nationwide ones, and secondly, the forecasts relate to just one week. The models are not, however, a substitute for thinking for yourself. Continuing to keep a sharp eye on the local situation is essential. In preparation for the next pandemic, Michael von Wagner, whose unit is responsible for sending the ensemble forecasts to Hessen's

THE PROCEDURE

The forecasting models for Hessen's hospitals have been in use since 5 March 2021. Forecasts are produced for the whole of Hessen as well as for the six catchment areas: Kassel, Fulda-Bad Hersfeld, Giessen-Marburg, Frankfurt-Offenbach, Wiesbaden-Limburg and Darmstadt. There are two data sources. First, the number of new infections, which the public health departments collect on a daily basis and transmit centrally to the Hessian State Healthcare Office, which reports to the Hessian Ministry of Social Affairs and Integration (HMSI). Second, ward occupancy, which Hessen's hospitals have been recording in the IVENA software system since the summer of 2020. The AP2 groups in the egePan Unimed project receive the data from these two sources once a week in an anonymous form and with no possibility to draw conclusions about individual patients. From these data and with their model, they calculate a forecast for each of Hessen's catchment areas. The individual results then land on the team's desks at von Wagner's unit in Frankfurt, who calculate the mean value with standard deviation, compile a graph and send both together to the HMSI in Wiesbaden. The HMSI forwards the overall forecast to the hospitals in Hessen.

hospitals, observes that "COVID-19 has made us conscious of our own vulnerability, but also that of a health system taken for granted." He considers the intensive care bed as a resource to be something like the bottleneck of general medical care. It has a tremendous influence on public life: If hospital wards become crowded, restrictions have to be imposed: lockdown! The forecasts produced in the framework of egePan Unimed help to keep the health system stable during the crisis. And after COVID-19 too, as von Wagner stresses. "The project is giving us standardised data and reporting channels – this represents fundamental progress."

Coordinating regional structures are in the process of developing that bring together service providers and state ministries in a "medical context". These structures still need to be transposed into abstract role models. "Then we can put them into practice rapidly in a new pandemic situation, which hopefully won't occur too soon, and adapt them to the new challenge." ●

The author

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THE UNIVERSITY MEDICINE NETWORK

In the early summer of 2020, all 34 university hospitals joined forces with the aim of developing new approaches to combat COVID-19. In this context, research, patient care and pandemic management are working together so that findings can be swiftly integrated into practice. The network should also help ensure a faster and more structured response to future epidemiological events. The projects include, for example, inter-hospital emergency admission registers, research on COVID-19 immunity, a Germany-wide autopsy network as well as nationwide standardised, data privacy-compliant infrastructures for storing COVID-19 research datasets and a national strategy for palliative care in times of pandemics. The Federal Ministry of Education and Research will fund the University Medicine Network with up to € 150 million. University Hospital Frankfurt is participating in eight of the current 13 collaborative projects and playing a leading role in three of them. Project leader for the University Medicine Network in Frankfurt is Professor Jürgen Graf, medical director and chairman of the board of University Hospital Frankfurt.

egePan Unimed (Development, testing and implementation of regionally adaptive care structures and processes for evidence-driven pandemic management coordinated by university medicine) is coordinated by the university hospitals in Frankfurt and Dresden and implemented in cooperation with 26 other university hospitals and external institutions. The project brings together experiences from regional, national and international pandemic management concepts on a sound scientific basis to create a prototypical model. The aim is to safeguard inpatient and outpatient care capacities by dovetailing a large number of system components.

NAPKON (National Pandemic Cohort Network) is a network of key infrastructures and cohort platforms aimed at forming a basis for understanding and combating COVID-19 and future pandemics. NAPKON takes care of the overall collection and use of clinical data and biospecimens and in so doing can draw on the preliminary work on the "German Corona Consensus Data Set" (GECCO). The project delivers a thorough documentation of data on preventive, diagnostic and therapeutic measures, including detailed information on current risk factors and potential biomarkers for disease progression – and can ultimately support the development of vaccines and effective therapeutics. Professor Janne Vehreschild from Medical Clinic 2 at University Hospital Frankfurt is the spokesperson for the project, which is jointly coordinated by five university hospitals.

RACOON (Radiological Cooperative Network) is the first project on this scale worldwide to set up a nationwide infrastructure for a systematically structured documentation of radiological data from COVID-19 cases. Radiological data make it possible to recognise, assess and track pulmonary infections triggered by a pandemic. Traditionally, results are entered as free text and are therefore unsuitable for automatic, machine-based evaluation. The structured recording method applied in the RACOON project forms the groundwork for processing large numbers of radiological results in real time. The aim is to use the highly structured data to assess situations and as an early warning system and to provide science with insights into the disease's mechanisms of action as well as into risk factors and therapies. RACOON is headed by Professor Thomas Vogl, director of the Institute for Diagnostic and Interventional Radiology at University Hospital Frankfurt, together with colleagues from Charité in Berlin.

CEO-sys (COVID-19 Evidence Ecosystem for the Improvement of Knowledge Management and Translation) will identify, process and analyse data and scientific publications on the COVID-19 pandemic. 21 universities and four external partners are contributing, including the Institute of Medical Microbiology and Hospital Hygiene in Frankfurt headed by Professor Volkhard Kempf. This will lead to the development of a dynamic, evidence-driven ecosystem that will offer the possibility to base therapy, care strategy and political decisions on the best current evidence available. Especially hygiene-related aspects, such as the emergence of bacterial superinfections which complicate patient care, are to be analysed in this context.

Projects involving University Hospital Frankfurt: The "B-FAST" project is a nationwide research network in the field of applied surveillance and testing. "COVIM" is concerned with establishing and making use of SARS-CoV-2 immunity. "DEFEAT PANDEMICs" is building up a nationwide autopsy network for pandemics, and "CODEX" is setting up a research data platform to make data on COVID-19 available in a standardised format.

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