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# Hospitalisations for COVID-19 – a comparison of different data sources

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## ORIGINAL ARTICLE

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## BACKGROUND

Three different data sources exist for monitoring COVID-19-associated hospitalisations in Norway: The Directorate of Health, the Norwegian Intensive Care and Pandemic Registry (NIPaR), and the linking of the Norwegian Patient

Registry (NPR) and the Norwegian Surveillance System for Communicable Diseases (MSIS). A comparison of results from different data sources is important to increase understanding of the data and to further optimise current and future surveillance. We compared results from the three data sources from March to June 2020.

## **MATERIAL AND METHOD**

We analysed the number of new admissions, as well as the total number of hospitalised patients and those on ventilatory support, reported per day and by regional health authority. The analysis was descriptive.

## **RESULTS**

The cumulative number of new admissions according to NPR-MSIS (n=1260) was higher than NIPaR (n=1153). The discrepancy was high early in the epidemic (93 as of 29 March). The trend in the number of hospitalised patients was similar for all three sources throughout the study period. NPR-MSIS overestimated the number of hospitalised patients on ventilatory support.

## **INTERPRETATION**

The discrepancy in new admissions between NIPaR and NPR-MSIS is primarily due to missing registrations for some patients admitted before NIPaR became operational. Basic information retrieved daily by the Directorate of Health give comparable results to more comprehensive daily information retrieval undertaken in NIPaR and NPR-MSIS, adjusted retrospectively. Further analysis is necessary regarding whether NIPaR and NPR-MSIS provide timely data and function as required in an emergency preparedness situation.

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### **Main findings**

Three different data sources for measurement of hospitalisations for COVID-19 (daily reports to the Directorate of Health/reporting to NIPaR/registry linkage of NPR and MSIS) gave comparable results.

NPR-MSIS included more new admissions than NIPaR per day at the start of the epidemic in Norway.

Daily registrations by the Directorate of Health have provided a good picture of the number of hospitalised patients per day during the epidemic when compared to figures from NIPaR and NPR-MSIS that had been adjusted retrospectively.

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Continuous monitoring of hospitalisations for COVID-19 is required to maintain an overview of the epidemiological situation and the burden on hospitals over time. During the pandemic, different countries have chosen different monitoring strategies at the national level. Some countries collect individual-level data from existing patient registries [\(1\)](#) or recently established

systems [\(2\)](#). Others have comprehensive systems for admissions to intensive care units, but not for new hospitalisations [\(3, 4\)](#). Not all countries have nationwide systems [\(5\)](#).

Most countries have implemented national monitoring of the burden on hospitals, either of all patients hospitalised for COVID-19 [\(1, 2, 6\)](#) and/or patients admitted to intensive care units [\(3\)](#). To collect daily information on COVID-19 patients who are hospitalised and/or in intensive care units in Norway, the Directorate of Health, the Norwegian Institute of Public Health and the Norwegian Intensive Care and Pandemic Registry (NIPaR) have established three different data sources: reporting from the hospitals to the Directorate of Health; NIPaR; and linking of raw data in the Norwegian Patient Registry (NPR) and data in the Norwegian Surveillance System for Communicable Diseases (MSIS).

During the influenza pandemic in 2009, weekly aggregated reporting of admissions to hospitals and intensive care units was established at the national level in Norway, since a continuous collection of data for use in routine surveillance of influenza did not previously exist [\(7\)](#). It was considered that the anonymity of the reporting made for a significant reduction in quality and eliminated the opportunity for further epidemiological research. Nor was this system coordinated with the regional health authorities [\(7\)](#). Since we now have a number of different systems for monitoring of hospitalisations for COVID-19 in Norway, and because these data are important for the management of the epidemic, it is essential to continuously compare figures from different monitoring systems to see whether they provide an identical picture of the situation. This may help increase our understanding of the data and optimise current and future surveillance. No comparisons have yet been made of the figures from the three different data sources that are used for monitoring of hospitalisations for COVID-19 in Norway.

The objective of this study was to compare the daily number of new admissions, as well as the daily total number of hospitalised patients and the number of patients on ventilatory support reported from the three data sources in the period March – June 2020 to see whether they provided a comparable picture of the epidemic in the country.

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## Material and method

### Data sources

The three data sources used for daily monitoring of hospitalisations for COVID-19 in Norway are summarised in Table 1. Although there is some overlap in the information that these three sources collect, the data sources differ in terms of their methods of data collection and definitions of hospitalisation. The Directorate of Health collects data on daily prevalence for a few key variables [\(8\)](#). The other two data sources are registry-based and collect personally identifiable data [\(9\)](#). A description of the patient group registered in NIPaR and

NPR-MSIS is published weekly in reports from the Norwegian Institute of Public Health (10). All three data sources collect data from all Norwegian hospitals, and reporting to all three is mandatory.

**Table 1**

Summary of the data sources for the Directorate of Health, the Norwegian Intensive Care and Pandemic Registry (NIPaR) and the linkage between the Norwegian Patient Registry and the Norwegian Surveillance System for Communicable Diseases (MSIS) for daily monitoring of hospitalisations for COVID-19 in Norway.

<b>Characteristic</b>	<b>Directorate of Health</b>	<b>Norwegian Intensive Care and Pandemic Registry</b>	<b>Linkage Norwegian Patient Registry and the Norwegian Surveillance System for Communicable Diseases</b>
Reporting method	Manual counting and reporting to the Directorate of Health	Data registered in the Norwegian Pandemic Registry (NoPaR) and the emergency preparedness form from the Norwegian Intensive Care Registry (NIR)	Data collected automatically with the aid of the NPR infrastructure. In addition, data from MSIS.
Data collected	Daily prevalence, including the number of patients hospitalised and on invasive ventilatory support	Personally identifiable information from NoPaR and NIR <sup>1</sup>	Personally identifiable information from NPR and MSIS <sup>1</sup>
Date of first data collection	12 March 2020	For NoPaR: 31 March 2020 For NIR: 10 March 2020	First half of April 2020
Data available from	8 March 2020	No limitation	1 January 2020
Time of data collection	Data are reported to the directorate before 12.00 and reflect the status as of 08.00 on the same day	Continuous data registration. The NIPH dataset is updated at 06.00 every day.	Continuous data registration. The linkage NPR-MSIS takes place at 09.00 every day.

Characteristic	Directorate of Health	Norwegian Intensive Care and Pandemic Registry	Linkage Norwegian Patient Registry and the Norwegian Surveillance System for Communicable Diseases
Definition of a hospitalisation for COVID-19	Patients with COVID-19 confirmed by a laboratory, including patients hospitalised with other diseases or injuries if these are considered contagious.	Patients with COVID-19 confirmed by a laboratory admitted to a hospital and/or intensive care unit, irrespective of reason for admission	Patients with COVID-19 confirmed by a laboratory, who were hospitalised in the period two days before until 14 days after sampling date, and/or inpatient admissions where the patient was diagnosed with U07.1

<sup>1</sup>For links to information on items registered in NPR, MSIS, NoPaR and NIR, see the Norwegian Institute of Public Health (9)

## Data processing

We retrieved data from the three sources on 29 June 2020. We included data from 1 March until 28 June 2020 from NIPaR and NPR-MSIS, and data from 8 March through 26 June from the Directorate of Health. The Directorate of Health does not have data prior to 8 March, and data were only reported on weekdays in June (8).

From NIPaR, all admission and discharge forms were linked to patient trajectories at the individual level. Ventilation periods were defined by the start and end times of the ventilatory support. New admissions with less than 24 hours between discharge and renewed admission were defined as a single hospitalisation episode. The same definition was applied to hospitalised patients on ventilatory support, but with a 12-hour time limit. The data set provided by NIPaR to the Norwegian Institute of Public Health does not distinguish between invasive and non-invasive ventilatory support.

From NPR, all admission and discharge dates were linked to patient trajectories at the individual level. New admissions with less than 24 hours between discharge and renewed admission were defined as a single hospitalisation episode. Ventilation periods were defined by the start time of the ventilatory support and the discharge date from the ward where ventilatory support was used, because of incomplete data on the time when the ventilatory support had ended. We used the code for invasive ventilatory support

(GXAV01) from the Norwegian clinical procedure coding system to define an invasive ventilatory support episode. We defined non-invasive ventilatory support as episodes for which codes had been entered for non-invasive treatment with continuous positive and/or biphasic positive airway pressure (GAXV10 and GAXV20 respectively).

In NIPaR and NPR-MSIS we defined a new admission as the first admission date per patient with confirmed COVID-19. Readmissions were not included in the count of new admissions. We defined a patient as hospitalised starting from the date after the admission date up to and including the last discharge date for the episode. An equivalent definition was used for hospitalised patients on ventilatory support.

## **Data analysis**

The data analysis was descriptive. We compared the number of new admissions in NIPaR and NPR-MSIS, as well as the total number of hospitalised patients and patients on ventilatory support in the Directorate of Health, NIPaR and NPR-MSIS per day and per regional health authority. We compared the number of hospitalised patients on ventilatory support in NPR-MSIS for all ventilation episodes and for invasive ventilation episodes only. Data processing and analysis were performed in STATA 16.0 and Microsoft Excel.

## **Ethics**

No approval by the Regional Committee for Medical and Health Research Ethics (REK) was required for the data from the Directorate of Health, since we were using aggregated and anonymous data that are publicly available. NIPaR and NPR-MSIS are included in the emergency preparedness registry for COVID-19, called Beredt C19, established by the Norwegian Institute of Public Health [\(9\)](#). A thorough data protection impact assessment (DPIA) of this registry has been made, and in its submission assessment on 2 June 2020, the Regional Committee of Medical and Health Research Ethics concluded that analyses of health service use fall outside the scope of the Health Research Act (REK South-Eastern Norway B, 153204).

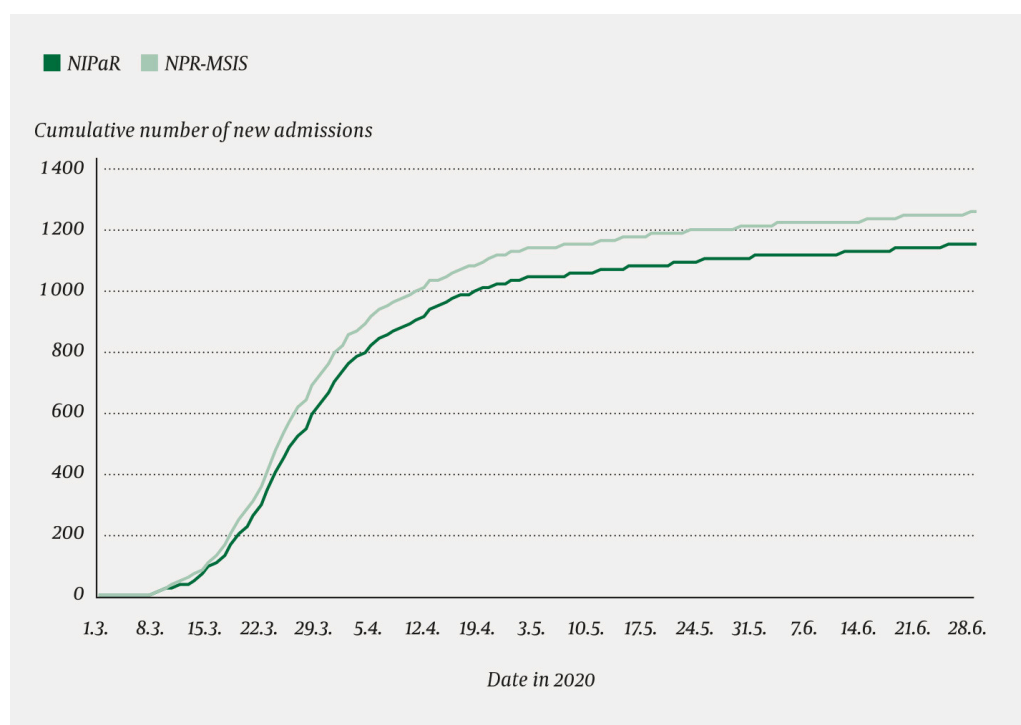
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## **Results**

### **New admissions to hospital**

The cumulative number of new admissions reported by NPR-MSIS (n=1260) was higher than in NIPaR (n=1153) throughout the study period. The discrepancy was high at the early stage of the epidemic (93 as of 29 March) (Figure 1). A similar trend was observed for all the regional health authorities, except for late in the period, when nearly all new admissions were in South-Eastern Norway Regional Health Authority (data not shown).

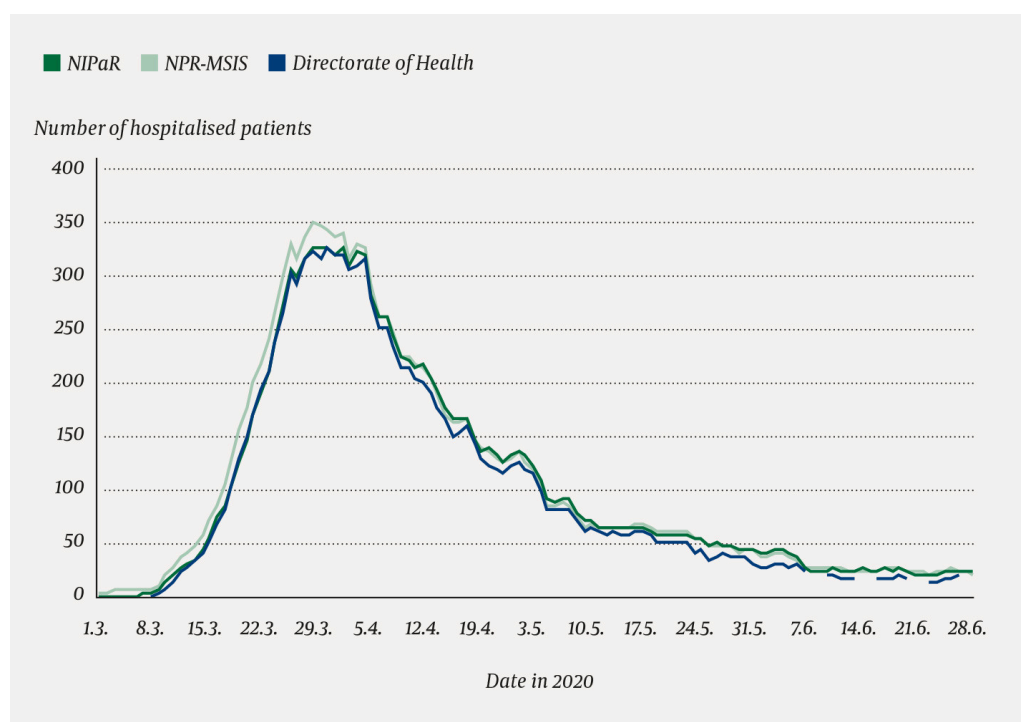




**Figure 1** Cumulative number of new admissions for confirmed COVID-19 per day in Norway according to the Norwegian Intensive Care and Pandemic Registry (NIPaR) and linkage between the Norwegian Patient Registry and the Norwegian Surveillance System for Communicable Diseases (MSIS) in the period 1 March – 28 June 2020. A new admission is defined according to the first date of admission per patient. Readmissions are not included.

## Hospitalised patients

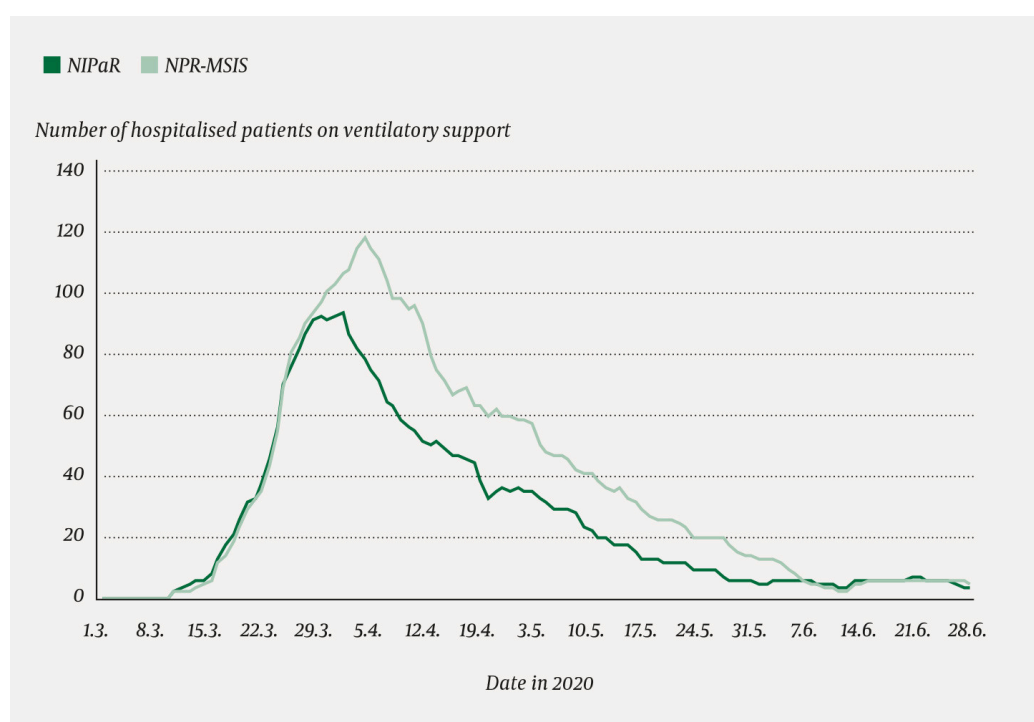
The trend in the number of hospitalised patients per day was consistent in all three data sources throughout the study period, with some daily variations (Figure 2). In March, there were on average 16 more hospitalised patients per day in NPR-MSIS than in NIPaR, and 21 more than in the figures from the Directorate of Health. The peak number was 351 (30 March) according to NPR-MSIS, 327 (31 March) according to NIPaR and 325 (1 April) according to the Directorate of Health. From 5 April to 28 June, the figures from both NPR-MSIS and NIPaR showed nine more hospitalised patients on average than the figures from the Directorate of Health (Figure 2).



**Figure 2** Number of hospitalised patients with confirmed COVID-19 per day in Norway according to the Norwegian Intensive Care and Pandemic Registry (NIPaR), linkage between the Norwegian Patient Registry and the Norwegian Surveillance System for Communicable Diseases (MSIS) and reporting to the Directorate of Health in the period 1 March – 28 June 2020.

## Ventilatory support

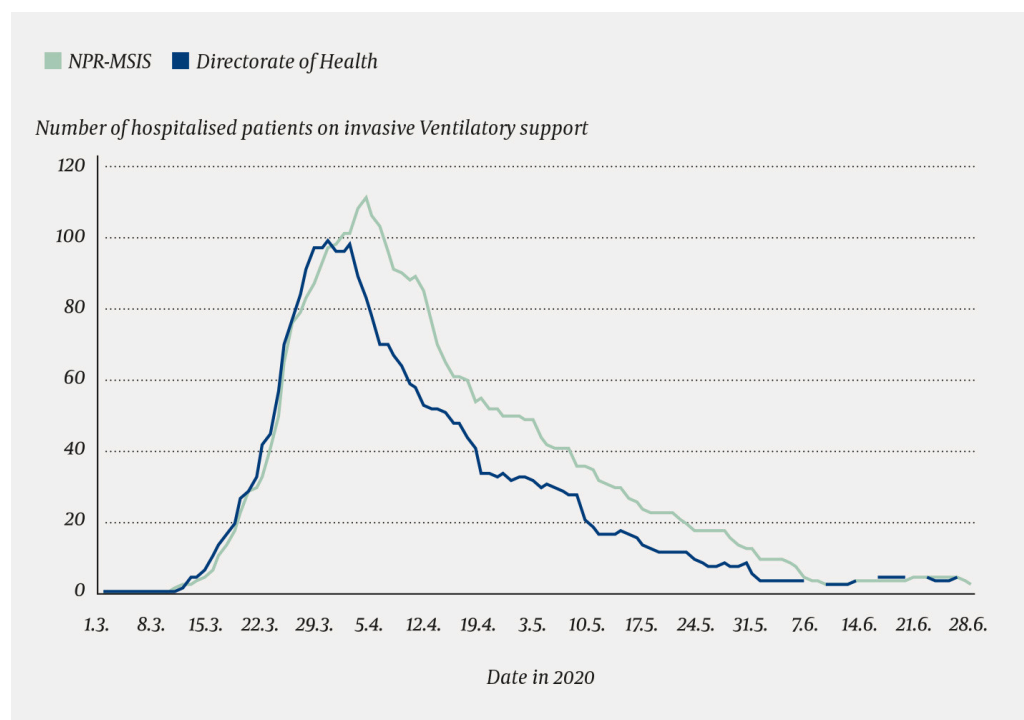
The trend in the number of hospitalised patients on ventilatory support in NPR-MSIS was similar to the trend in NIPaR at the start and end of the study period. From 5 April until 31 May, there were on average 21 more patients on ventilatory support in NPR-MSIS than in NIPaR. The peak number of hospitalised patients on ventilatory support was 94 (3 April) according to NIPaR and 118 (6 April) according to NPR-MSIS (Figure 3).



**Figure 3** Number of hospitalised patients with confirmed COVID-19 and need for ventilatory support per day according to the Norwegian Intensive Care and Pandemic Registry (NIPaR) and linkage between the Norwegian Patient Registry and the Norwegian Surveillance System for Communicable Diseases (NPR-MSIS) in the period 1 March–28 June 2020.

### Invasive ventilatory support

The trend in the number of hospitalised patients on invasive ventilatory support in NPR-MSIS was similar to the trend for the Directorate of Health at the start and end of the study period. From 5 April until 31 May, there were on average 15 more patients on invasive ventilatory support in NPR-MSIS than are indicated by the figures from the Directorate of Health. The peak number was 99 (1 April) according to the Directorate of Health and 111 (6 April) according to NPR-MSIS (Figure 4).



**Figure 4** Number of hospitalised patients with confirmed COVID-19 and need for invasive ventilatory support per day according to linkage between the Norwegian Patient Registry and the Norwegian Surveillance System for Communicable Diseases (NPR-MSIS) and data reported to the Directorate of Health in the period 1 March–28 June 2020.

## Discussion

This analysis is the first comparison of different data sources that collect data on hospitalisations for COVID-19 in Norway, and as far as we are aware the first to compare results from three different data sources. Few similar analyses from other countries have been published. In an analysis of two different data sources on hospitalisations for COVID-19 in Belgium, 71 per cent of hospitalisations were registered in a system that was based on voluntary reporting of individual-level data, compared with a mandatory reporting system based on collection of aggregated data (2). In our study, there were

nearly one hundred more new admissions for COVID-19 in NPR-MSIS than in NIPaR at the start of the study period, and more hospitalised patients per day in March. This could be due to some patients admitted to hospital before the pandemic registry came into operation not being registered retrospectively, or patients without a national identity number or a D-number (a temporary identity number for foreign residents) not being able to be registered. Since November 2020 it has been possible to link NIPaR to MSIS in the Beredt C19 registry, which enables further analysis of differences between these two data sources in terms of patients registered.

The trend in the number of hospitalised patients per day in the three sources confirms that the figures reported to the Directorate of Health have given a good picture of the situation in Norway during the COVID-19 pandemic. Day-to-day variation between the data sources in the number of hospitalised patients can be due to differences in data collection practices and in the ways in which patient trajectories are collated. The reporting to the Directorate of Health was crucial at the start of the COVID-19 pandemic when the other two data sources were unavailable, and it also reveals a gap in preparedness that also came to light in connection with the influenza pandemic in 2009, both in Norway (7, 11) and internationally (12, 13). The reporting to the Directorate of Health required a manual daily count, at a time when the health authorities were facing a substantial workload. The concurrent results give grounds for assessing whether NIPaR and NPR-MSIS can replace the hospitals' reporting to the Directorate of Health. It is desirable to have automated systems in place that use existing data instead of manual solutions, but both of these approaches are required for the time being.

The daily data retrievals from the hospitals' electronic systems (NPR) that have been established during the pandemic are a major step in the direction of updated registry information from the Norwegian specialist health service. A continuation of this practice also after the pandemic will be important to improve the national monitoring of future known and unknown serious health threats. NPR-MSIS provides a quick and complete registration of admissions and discharges of patients infected by SARS-CoV-2, because the linkage is largely based on established reporting procedures. On the other hand, it is difficult to determine whether the patient is being treated for COVID-19 or for some other disease or injury. Registration in NIPaR requires is done manually, and thereby has similar disadvantages to those of registration by the Directorate of Health. The advantage is that NIPaR collects far more clinical information, which makes this source well suited for analysing the condition of COVID-19 patients and the therapeutic procedures that are initiated.

As national registries, NIPaR and NPR-MSIS can be used for ongoing research and surveillance of COVID-19. If the information in NIPaR and NPR-MSIS is also to be used in the context of emergency preparedness, it is essential that these data sources provide updated, real-time information on the workload in hospitals that can quickly be fed back to decision-makers. In an emergency preparedness situation, information gathering needs to be robust and feasible without burdening the health services, especially the clinicians. Information ought to be collected from persons without a national ID number or D-number as well as from any recently established hospitals and intensive care units.

This study is retrospective, and the information from NIPaR and NPR-MSIS has been adjusted retrospectively. This may explain why more hospitalised patients were generally registered in NIPaR and NPR-MSIS than in the figures from the Directorate of Health. The results are therefore not transferable to an emergency preparedness situation where daily updated information is required. An analysis based on a daily data retrieval from NIPaR and NPR-MSIS must be undertaken over a period to be able to assess whether these data sources are suitable as replacements for the hospitals' reporting to the Directorate of Health.

The number of patients on ventilatory support was higher in NPR-MSIS than in NIPaR, and the number of patients on invasive ventilatory support was higher in NPR-MSIS than in the figures from the Directorate of Health. In NPR-MSIS, the end time of ventilatory support was based on the time of discharge from the ward, due to incomplete or missing data for end time of ventilatory support. Most likely, this has led to an overestimation of the number of patients on ventilatory support at any given time. NIPaR is therefore better suited to measure the time on ventilatory support. Another possibility is to increase the quality of the coding of start and end times for implemented interventions and procedures in NPR.

## Conclusion

In combination, the three different data sources provide good information on hospitalisations for COVID-19 for the various purposes that are relevant in an emergency preparedness situation, on an ongoing basis as well as in retrospect. The figures reported to the Directorate of Health have provided a good picture of the daily number of COVID-19 patients in Norway. Further analysis is required as to whether NIPaR and NPR-MSIS provide real-time data and function well in an emergency preparedness situation.

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