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# Peak Health Care Burden During the First Three COVID-19 Waves in the Republic of Croatia

## Vršna opterećenja zdravstvenog sustava tijekom prva tri vala COVID-19 pandemije u Republici Hrvatskoj

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### Summary

**Introduction:** One of the main concerns during the COVID-19 pandemic was the overload of health care sector capacities. The objective of this paper was to show peak numbers of selected indicators during the three COVID-19 waves in Croatia and ensure information that will enable revision of preparedness plan and potential hospitals' (re)organization.

**Methods:** Retrospective analysis of COVID-19 testing, infections, hospitalizations, ICU admissions, mechanical ventilation support and deceased data collected via capacity surveillance in the Republic of Croatia during the first three waves.

**Results:** Peak hospital bed occupancy rates observed in the 2nd and 3rd waves were 70.19% and 54.60%, compared to maximum capacity during the COVID-19 wave, and 168.90% and 131.38%, compared to maximum capacity between waves, while ICU beds occupancy rates were 75.51% and 70.73%, and 170.51% and 160.37%, respectively. Peak daily numbers were as follows (first/ second/third wave); positive persons: 53/4827/3198; tested persons: 1984/13325/11622; total hospitalized persons: 372/2976/2315; total mechanical ventilation needed: 31/306/278; total ICU hospitalized: unknown/370/348; deceased: 8/92/52.

**Conclusion:** During pandemic waves, the requirements for hospital and ICU beds significantly exceeded standard available health sector capacities. The system has acutely adjusted by increasing the number of beds available for COVID-19 patients. However, given the peaks observed so far, a permanent additional increase or reorganization of hospital capacity is needed to ensure that during the upcoming waves non-COVID-19 and COVID-19 patients won't be endangered or part of the staff overloaded.

### Sažetak

**Uvod:** Preopterećenje kapaciteta zdravstvenog sustava predstavlja jednu od glavnih prijetnji tijekom COVID-19 pandemije. Cilj je prikazati vršne vrijednosti odabranih indikatora tijekom COVID-19 valova u RH i osigurati informacije koje će omogućiti reviziju plana spremnosti i moguću re(organizaciju) rada bolnica.

**Metode:** Retrospektivna analiza rezultata COVID-19 testiranja, infekcija, hospitalizacija, JIL popunjenosti te podataka o osobama na respiratoru i preminulih prikupljenih sustavom nadzora kapaciteta tijekom prva tri vala u RH.

**Rezultati:** Vršna popunjenost bolničkih kreveta opažena u 2. i 3. valu bila je 70,19% i 54,60%, u usporedbi s maksimalnim kapacitetima raspoloživim tijekom COVID-19 valova, te 168,90% i 131,38%, u usporedbi s kapacitetima dostupnima između dva vala, JIL kreveta 75,51% i 70,73% odnosno 170,51% i 160,37%. Vršne dnevne vrijednosti bile su kako slijedi (prvi/drugi/treći val); pozitivni: 53/4827/3198; testirani: 1984/13325/11622; ukupno hospitalizirani: 372/2976/2315; ukupno na respiratoru: 31/306/278; ukupno JIL hospitalizirani: nepoznato/370/348, preminuli: 8/92/52.

**Zaključak:** Tijekom korona valova, zahtjevi za bolničkim i JIL posteljama značajno su nadmašili postojeće standardne kapacitete zdravstvenog sustava. Sustav se akutno uspio prilagoditi povećanjem broja raspoloživih kreveta za COVID-19 pacijente. Međutim, obzirom na do sada opažene vršne vrijednosti, potrebno je trajno dodatno povećanje ili reorganizacija bolničkih kapaciteta koji bi osigurali da se tijekom predstojećih valova izbjegne ugroza zdravlja ne-COVID-19 i COVID-19 bolesnika te preopterećenja dijela osoblja.

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## Introduction

The COVID-19 pandemic started in the Republic of Croatia on February 26, 2020 and manifested in 3 waves so far while the fourth wave is still developing. The epidemic has provoked public health and policy makers' response in terms of non-pharmaceutical interventions as previously published<sup>[1]</sup>. Furthermore, with the vaccination start in the late December 2020, additional measures in prevention of COVID-19 disease and severe COVID-19 disease were available. The effect of applied non-pharmaceutical intervention measures and vaccination was a decrease of peak burden. However, the extent to which the hospital capacities were loaded are still not systematically analysed in Croatia.

The objective of this paper was to show maximum reported numbers during the three waves of COVID-19 infection, tests performed, hospitalizations, ICU admissions and discharges, patients requiring mechanical ventilation and deaths, in order to provide information necessary for adequate preparedness in the forthcoming waves. Potential hospitals' (re) organization is needed in order to avoid overload of one part of the medical staff, or at least decrease it, and ensure health care availability for COVID and non-COVID patients in the future.

## Methods

The data on COVID-19 hospitalizations, ICU admissions and discharges, patients requiring mechanical ventilation and deaths were collected daily, directly from hospitals (n=56) through LimeSurvey platform operated by the Croatian Institute of Public Health (CIPH)<sup>[2]</sup>. The survey collects daily numbers of COVID-19 admissions, discharges, deaths and hospital beds and ICU capacities. The survey also inquires about mechanical-ventilators capacities. However, the reported numbers are inconsistent and need further confirmation and therefore are not included. Daily data on COVID-19 testing including the test results were collected from the central platform for COVID-19 testing.

The start of official data collection was February 26, 2020 for testing data, and April 15, 2020 for hospitalization and mechanical-ventilation-support. The start date for ICU bed occupancy data collection was December 5, 2020 which was also the start date for hospital beds and ICU bed capacity data collection. The end date of the third wave, July 4, 2021, was defined as the end of the study period.

Data used for this study have been collected on a daily basis as part of COVID-19 capacity surveillance

and they have been regularly collected in Excel spreadsheets on a weekly basis. These spreadsheets were used for analysis in this study.

Percentage of used beds capacity was calculated as “% of maximum capacity” which is the number of occupied beds divided by maximum numbers of beds available during the periods between two COVID-19 waves; and “adjusted % of maximum capacity” which is the number of occupied beds divided by maximum numbers of beds available during periods of active COVID-19 waves. Since the numbers of available beds were changing during the time and sometimes varied from week to week as a result of demands or estimated future demands, the average number of COVID-19 beds available between waves was calculated as a mean of daily available beds during predefined period. Testing data includes PCR tests from the beginning of epidemics. Daily number of positives and performed tests represent the numbers of distinct positives/tested persons on the exact date as well as the total number of hospitalized and ICU hospitalized persons, people requiring mechanical ventilation support and deceased persons.

COVID-19 waves estimated start dates were defined as the start of COVID-19 positives increases and end dates as end of COVID-19 positives declines, taking into account reproductive number, growth rate and testing positivity rate.

## Results

From February 26, 2020 until July 4, 2021, there were 360.244 persons with COVID-19 positive tests, 2.218.011 tests conducted, 41.433 hospitalizations, and 8.216 deceased persons with or from COVID-19.

The numbers of tested persons and COVID-19 positive persons per week describing the three observed waves are presented in Figure 1.

Selected COVID-19 indicators including peak numbers and occupancy rates during the observed waves of COVID-19 pandemic in Croatia are shown in Table 1.

FIGURE 1. COVID-19 WAVES IN CROATIA

SLIKA 1. VALOVI COVID-19 U HRVATSKOJ

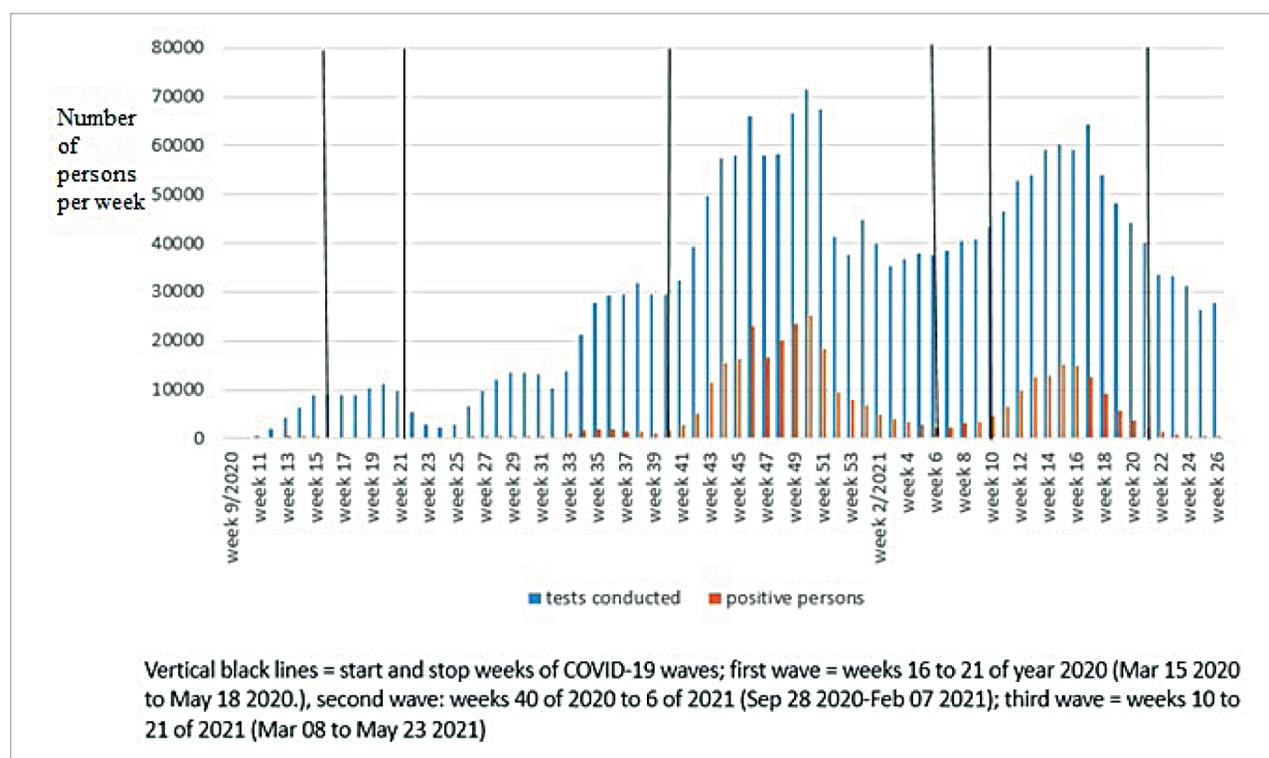


TABLE 1. MAXIMUM NUMBERS AND OCCUPANCY RATES

TABLICA 1. VRŠNE VRIJEDNOSTI I STOPE POPUNJENOSTI

COVID-19 wave	First April 15, 2020 to May 18, 2020	Second September 28, 2020 to February 7, 2021	Third March 8, 2021 to May 23, 2021
Duration (weeks)	5	19	11
Max number of positive tests/ day	53	4827	3198
Max number of tests/ day	1984	13325	11622
% of max testing capacity	14,89	100,00	87,22
Max total number of hospitalized persons/ day	372	2976	2315
Adjusted % of max COVID beds <sup>b</sup>	8,77	70,19	54,60
% of max COVID beds	No denominator available	168,90	131,38
% of average number of COVID beds available between the 2 <sup>nd</sup> and 3 <sup>rd</sup> wave	No denominator available	95,60	74,37
% of average number of COVID beds after the end of the 3 <sup>rd</sup> wave	No denominator available	131,41	102,23
Max total number of persons requiring mechanical ventilation support/ day	31	306	278
Max total number of deceased/ day	8	92	52
Max total number of patients in ICU/ day	No denominator available	370	348
Adjusted % of max ICU COVID beds <sup>b</sup>	No denominator available	75,51	70,73

% of max ICU COVID beds	No denominator available	170,51	160,37
% of average number of ICU COVID beds between the 2 <sup>nd</sup> and 3 <sup>rd</sup> wave	No denominator available	105,30	99,04
% of average number of ICU COVID beds after the end of the 3 <sup>rd</sup> wave	No denominator available	129,98	139,94

<sup>a</sup> % of max testing capacity = max capacity considered as max number of tests ever conducted in a single day

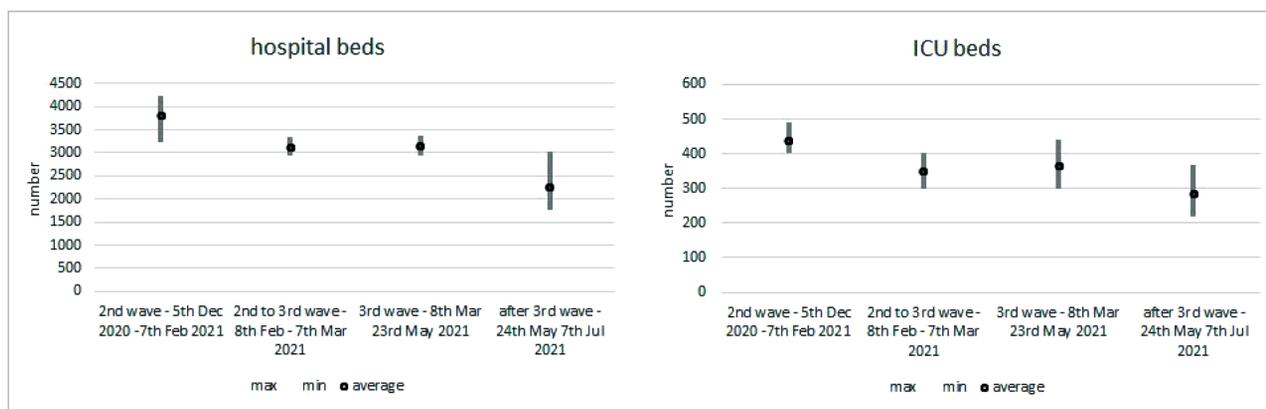
<sup>b</sup> Adjusted % = % during the wave

The number of daily available hospital and ICU COVID-19 beds varied on a daily basis with trend of additional ensuring of beds i.e. increasing capacity during the waves, although the occasional independence of COVID-19 waves was present. Since mechanical venti-

lator capacities were not available, their occupancy rate was not possible to calculate.

Reported capacities, i.e., available hospital and ICU beds for COVID-19 patients with minimum, maximum and average beds are presented in Figure 2.

FIGURE 2. AVAILABLE HOSPITAL AND ICU BEDS FOR COVID-19 PATIENTS IN CROATIA (54 HOSPITALS) DURING AND BETWEEN WAVES PERIOD  
 SLIKA 2. DOSTUPNI BOLNIČKI I JIL KREVETI ZA COVID-19 BOLESNIKE U HRVATSKOJ (54 BOLNICE), TIJEKOM I IZMEĐU VALOVA



### Discussion

The objective of this paper was to show maximum reported numbers during the three COVID-19 waves of COVID-19 testing, infections, hospitalizations, ICU admissions, mechanical ventilation support and deceased persons in order to provide information necessary for hospitals` (re)organization and preparedness for future waves. During the peak numbers, hospital bed and ICU bed occupancy rates were higher than usually available (during non-waves periods). The availability of hospital and ICU beds is not a constant number, it is changing on a daily basis and it especially varied between periods of COVID-19 waves and periods without waves. This shows that hospitals were flexible when it comes to number of beds, probably at the expense of non-COVID-19 patients. The significant reduction of non COVID-19 hospitalizations and non-elective interventions in Croatia is already documented<sup>[3]</sup>, however the effect of reducing non-COVID-19 beds on health indicators is yet to be seen in Croatia.

The solutions for preventing hospital capacities being overstretched include increasing of hospital capacities, hospitals` re-organization or introducing non-pharmaceutical interventions (NPIs) aimed at reducing/suppressing COVID-19 in communities. The matter of effectiveness of NPIs vs. their impact on the quality of life, economy and health is still a matter of scientific research<sup>[4, 5]</sup>. However, information regarding available models for preparing scenario-based plans for responding to COVID-19 or similar type of outbreak are available<sup>[6, 7]</sup>, the only question is can we further improve our preparedness plans too. Although there are some guidelines for the situations when needs exceed capacity, there is limited consensus on how to allocate the finite resource in such demanding period<sup>[7]</sup>. Since the need for hospitalization is much rarer even in fully vaccinated patients, vaccination reduces the need for emergency care in breakthrough COVID-19 infections<sup>[8]</sup> and therefore the need for supportive strategy in preservation of hospital capacities, avoiding the overload of part of the medical staff,

and ensuring health care availability for COVID and non-COVID patients in the future.

### Study limitations

Data on the number of hospitalized and deceased persons presented in this paper are collected via daily hospital surveying. However, there is no confirmation if these people were hospitalized or deceased due to COVID-19 or due to another disease but with a positive COVID-19 test as an incidental finding. Also, reporting methodology regarding hospital beds is the same, via hospital surveys and not via official routine statistics. According to the routine statistics there were 4.478 deaths due to COVID-19 in 2020<sup>[9]</sup> while hospital surveying revealed 4.113 deaths with or from COVID-19 in 2020. However, besides the out-of-hospital COVID-19 deaths, unpublished preliminary data analysis revealed substantial agreement between those two sources (0.78). Since PCR tests were performed only in official laboratories within the National Health Insurance Fund network, with validation performed within each laboratory, we believe that the reliability of testing data should be acceptable. However, testing capacity, especially during the peaks, could have limited the numbers of positive patients.

### Conclusion

During the three already observed COVID-19 waves in Croatia, pandemic requirements for hospital and ICU beds significantly exceeded standard available capacities. Nevertheless, the healthcare system acutely adjusted by increasing available COVID-19 beds, as the extent of observed overload potentially endangered the whole sector as well as COVID-19 and non-COVID-19 patients. Sustainable permanent increase or reorganization of hospital capacities that can enable health sector to avoid medical staff overload and potential threats to the availability of health care to all patients are needed. This study also provides baseline data for future custom predictive models that can enable us to efficiently estimate future needs and empower us to build real preparedness plans and not just last-minute adjustments.

### Conflict of Interest

Authors do not have an association that might pose a conflict of interest.

### Funding

None to declare.

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