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The impact of the COVID-19 pandemic on hospital functioning and mortality among non-COVID-19 patients

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ABSTRACT

Introduction: The pandemic resulted in significant changes in the work organization within medical facilities, mainly hospitals, which were handling the largest numbers of people infected with SARS-CoV-2. The objective of the study was to analyse the impact of the COVID-19 pandemic on the functioning of Antoni Jurasz University Hospital No. 1 in Bydgoszcz as a whole, as well as consider individual departments.

Material and methods: The data were acquired from the database of Antoni Jurasz University Hospital No. 1 in Bydgoszcz and included: the average length of hospitalization, number of hospitalizations, and number of deaths, as well as COVID-19 status. Information was collected for each month in the 2020–2021 period with a distinction between specific departments.

Results: The highest percentage of COVID-19 hospitalizations as well as the highest percentage of COVID-19 deaths were noted from October 2020 to May/June 2020 and in November and December 2021. Correlations between new monthly COVID-19 cases in Kuyavian-Pomeranian Voivodeship and several parameters (average length of hospitalization, total number of hospitalizations, mortality among non-COVID-19 patients) have been established for selected departments.

Conclusions: The analysis of the two years of the COVID-19 pandemic in Antoni Jurasz University Hospital No. 1 in Bydgoszcz, Poland, found in selected departments a significantly increased in-hospital mortality, decreased number of hospitalizations, and decreased length of stay. Departments exhibiting an opposite impact of the pandemic on the average length of hospitalization were identified.

Key words: SARS-CoV-2, COVID-19, pandemic, hospital functioning, clinical outcome

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Introduction

The first confirmed case of coronavirus disease 2019 (COVID-19) was reported in Poland on March 4, 2020 [1], while in the Kuyavian-Pomeranian Voivodeship on March 17, 2020 [2]. The causative virus is transmitted from person to person and spreads quickly between geographical locations [3], which significantly affects every area of our lives, especially the functioning of the healthcare system.

The pandemic resulted in significant changes in the work organization within medical facilities, mainly hospitals, which were handling the largest numbers of people infected with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Due to the rapid spread of the virus, individual hospital departments as well

as entire medical facilities had to implement changes in their day-to-day operations. The epidemiological situation worldwide and in Poland specifically, led to the enforcement of specific procedures in case of confirmation of COVID-19 in patients or medical staff, which greatly affected hospitals functioning. Limited hospital admissions, compulsory quarantines, and the establishment of COVID-19 isolation wards have disrupted the existing medical services. This applied not only to people with a confirmed SARS-CoV-2 infection but also to patients using hospital services for non-COVID-19-related reasons during the pandemic. The objective of the study was to analyse the impact of the COVID-19 pandemic on the functioning of Antoni Jurasz University Hospital No. 1 in Bydgoszcz as a whole, as well as consider individual departments.

Material and methods

The data were acquired from the database of Antoni Jurasz University Hospital No. 1 in Bydgoszcz and included: the average length of hospitalization, number of hospitalizations, and number of deaths. The COVID-19 status of the patients was also obtained. The data were collected for each month in the 2020–2021 period with a distinction between specific departments. Each department was assigned a number (Tab. 1). Isolation wards were excluded due to their specifications and temporariness. Publicly available data on the number of new COVID-19 cases in the Kuyavian-Pomeranian Voivodeship [4], where Antoni Jurasz University Hospital No. 1 is located, was used as a reference point.

Statistical analysis was carried out using the Statistica 13.3 package (TIBCO Software Inc, California, USA). In the analysis non-parametric tests were used. Categorical variables were presented as numbers and percentages. Comparisons between two and four groups were carried out using the χ^2 test. To estimate the correlation between two quantitative variables, Spearman's rank correlation was used. Results were considered significant at $p < 0.05$.

Results

The highest percentage of COVID-19 hospitalizations as well as the highest percentage of COVID-19 deaths were noted from October 2020 to May/June 2020 and in

Table 1. Departments of Antoni Jurasz University Hospital No. 1 in Bydgoszcz with assigned numbers

Department number	Department name
1	Department of Anaesthesiology and Intensive Care with a Subdivision of Cardioanaesthesiology
2	Department of Anaesthesiology and Intensive Therapy
3	Department of Vascular Surgery and Angiology
4	Department of General Surgery, Liver Surgery and Transplant Surgery
5	Department of Eye Diseases
6	Department of Dermatology, Sexually Transmitted Diseases and Immunodermatology
7	Department of Endocrinology and Diabetology
8	Department of Geriatrics
9	Department of Cardiac Surgery
10	Department of Cardiology
11	Department of Nephrology, Hypertension and Internal Medicine
12	Department of Neurosurgery, Neurotraumatology and Paediatric Neurosurgery
13	Department of Neurology
14	Department of Otolaryngology and Laryngological Oncology with the Subdivision of Audiology and Phoniatics
15	Department of Paediatrics, Allergology and Gastroenterology
16	Department of Paediatrics, Haematology and Oncology
17	Department of Transplantology and General Surgery
18	Department of General and Oncological Urology
19	Department of General and Oncological Surgery for Children and Youth
20	Department of Orthopaedics and Traumatology of the Locomotor System
21	Department of Palliative Medicine
22	Department of Neurological Rehabilitation
23	Department of Brain Strokes
24	Paediatrics Admission Room
25	Subdivision of Neonatology Intensive Care and Neonatal Surgery
26	Hospital Emergency Department
27	Nursing and Treatment Institute

Table 2. Hospitalizations and deaths, considering COVID-19 status, in the entire hospital for each month in the years 2020–2021

Year	Month	Total hospitalizations	Percentage of COVID-19 hospitalizations	Total deaths	Mortality	Percentage of COVID-19 deaths
2020	January	6759	0.00%	68	0.99%	0.00%
	February	6473	0.00%	56	0.86%	0.00%
	March	4920	0.00%	61	1.22%	0.00%
	April	3451	0.03%	69	1.97%	0.00%
	May	4961	0.00%	65	1.29%	0.00%
	June	6045	0.00%	83	1.36%	0.00%
	July	6620	0.00%	75	1.12%	0.00%
	August	6258	0.00%	64	1.01%	0.00%
	September	6343	0.06%	62	0.97%	0.00%
	October	5858	2.68%	75	1.26%	10.67%
	November	4865	4.01%	75	1.52%	12.00%
	December	5041	3.81%	106	1.91%	18.87%
2021	January	5377	3.24%	83	1.53%	15.66%
	February	5602	1.96%	74	1.31%	8.11%
	March	5901	3.29%	93	1.56%	12.90%
	April	5681	4.63%	87	1.51%	34.48%
	May	6315	1.08%	100	1.57%	18.00%
	June	6777	0.00%	70	1.02%	1.43%
	July	6538	0.05%	72	1.09%	0.00%
	August	6450	0.00%	74	1.14%	0.00%
	September	6622	0.02%	67	1.00%	0.00%
	October	6812	0.26%	86	1.25%	0.00%
	November	5874	2.13%	79	1.33%	10.13%
	December	5491	3.26%	78	1.40%	6.41%

November and December 2021. In this period the total number of hospitalizations decreased. Specific data for each month are presented in Table 2.

Correlations between new monthly COVID-19 cases in Kuyavian-Pomeranian Voivodeship and several parameters (average length of hospitalization, total number of hospitalizations, mortality among non-COVID-19 patients) have been calculated for each department using Pearson correlation coefficient (Tab. 3).

A statistically significant positive correlation between new monthly COVID-19 cases and an average length of hospitalization was found for departments 1 and 8, that is Department of Anaesthesiology and Intensive Care with a Subdivision of Cardioanaesthesiology and Department of Geriatrics. Negative correlations were identified and deemed statistically significant for departments 3, 7, 9, 10, 11, 16, 17, 21, 23, and 27. The strongest negative correlation was observed in department 21, Department of Palliative Medicine ($r = -0.8467$; $p < 0.05$).

The total number of hospitalizations correlated negatively with new monthly COVID-19 cases in Kuyavian-Pomeranian Voivodeship in departments 2, 6, 7, 8, 13, 16, 22, and 27.

A positive and statistically significant correlation between mortality among non-COVID-19 patients and the number of new COVID-19 cases have been identified for departments 1, 2, 3, 10, and 12. The Department of Endocrinology and Diabetology (department 7) showed a statistically significant negative correlation; however, further analysis showed no impact of the pandemic on the survival and deaths of non-COVID-19 hospitalized patients in this department.

Due to the variability of the number of new COVID-19 cases in the years 2020–2021 in Kuyavian-Pomeranian Voivodeship, the entire analysed period was divided into periods 1 and 2, where period 1: monthly level of new COVID-19 infections < 1000 ; period 2: monthly level of new COVID-19 infections > 1000 .

Table 3. Correlations between new monthly COVID-19 cases in Kuyavian-Pomeranian Voivodeship and the average length of hospitalization, the total number of hospitalizations, and mortality among non-COVID-19 patients for each department

Department	The average length of hospitalization		Total number of hospitalizations		Mortality among non-COVID-19 patients	
	r	p-value	r	p-value	r	p-value
1	0.46	0.02	-0.25	0.24	0.43	0.03
2	0.21	0.32	-0.73	0.00	0.52	0.01
3	-0.51	0.01	-0.15	0.49	0.49	0.02
4	0.09	0.67	0.01	0.96	0.25	0.25
5	-0.17	0.44	0.03	0.91	0.00	0.00
6	-0.31	0.14	-0.41	0.04	-0.04	0.84
7	-0.61	0.00	-0.63	0.00	-0.56	0.01
8	0.54	0.01	-0.53	0.01	-0.04	0.85
9	-0.69	0.00	-0.24	0.27	0.24	0.27
10	-0.51	0.01	-0.27	0.20	0.52	0.01
11	-0.45	0.03	0.14	0.50	0.17	0.44
12	0.15	0.49	-0.35	0.09	0.42	0.04
13	0.19	0.38	-0.55	0.00	0.21	0.31
14	0.08	0.71	-0.21	0.33	-0.23	0.27
15	0.27	0.20	-0.28	0.19	0.00	0.00
16	-0.57	0.00	-0.42	0.04	-0.28	0.18
17	-0.54	0.01	-0.07	0.75	-0.11	0.61
18	0.14	0.50	-0.35	0.10	-0.15	0.50
19	0.06	0.79	-0.11	0.60	-0.16	0.45
20	-0.19	0.36	0.01	0.95	-0.16	0.46
21	-0.85	0.00	-0.02	0.93	0.11	0.60
22	-0.34	0.10	-0.61	0.00	0.31	0.15
23	-0.57	0.00	-0.12	0.56	0.08	0.72
24	0.00	0.00	-0.28	0.19	0.00	0.00
25	0.09	0.66	0.27	0.19	0.00	0.00
26	-0.02	0.92	-0.34	0.10	0.37	0.08
27	-0.43	0.04	-0.59	0.00	-0.02	0.92

Additionally, period 1 consists of subperiods 1a and 1b, while period 2 of subperiods 2a and 2b. The subperiods go forward as follows: 1a: January 2020 — August 2020; 2a: September 2020 — May 2021; 1b: June 2021 — September 2021; 2b: October 2021 — December 2021.

The departments previously identified as having a positive correlation between mortality among non-COVID-19 patients and the number of new monthly COVID-19 cases in Kuyavian-Pomeranian Voivodeship (departments 1, 2, 3, 10, and 12) have been further analysed, taking into account the predefined periods as shown in Tables 4 and 5. In period 1, the total mor-

tality in the selected departments was 4.2%, while in period 2, the mortality was 6.4%. This indicates a significant increase ($p < 0.0001$) in mortality in the period when the monthly level of new COVID-19 infections in the Kuyavian-Pomeranian Voivodeship was above 1000 people (Tab. 4), showing that total mortality in the selected departments correlated with the number of new COVID-19 infections in the region (Fig. 1).

In the subperiods 1a, 2a, 1b, and 2b, the mortality rates in selected departments were 4.3%, 5.2%, 3.9%, and 5.8%, respectively. This analysis indicated that the mortality rates were significantly higher ($p < 0.0021$) in periods 2a and 2b compared with periods 1a and 1b (Tab. 5).

Table 4. Mortality in the selected departments with a distinction between prespecified periods: period 1: monthly level of new COVID-19 infections < 1000; period 2: monthly level of new COVID-19 infections > 1000

Department	Period 1			Period 2			p-value
	Survival	Deaths	Mortality	Survival	Deaths	Mortality	
Department of Anaesthesiology and Intensive Care with a Subdivision of Cardioanesthesiology	753	20	2.6%	699	24	3.3%	0.40226
Department of Anaesthesiology and Intensive Therapy	551	144	20.7%	414	213	34.0%	< 0.00001
Department of Vascular Surgery and Angiology	1314	14	1.1%	1204	30	2.4%	0.00735
Department of Cardiology	4014	145	3.5%	3772	200	5.0%	0.00053
Department of Neurosurgery, Neurotraumatology and Paediatric Neurosurgery	1448	27	1.8%	1275	38	2.9%	0.06321
Summary	8080	350	4.2%	7364	505	6.4%	< 0.0001

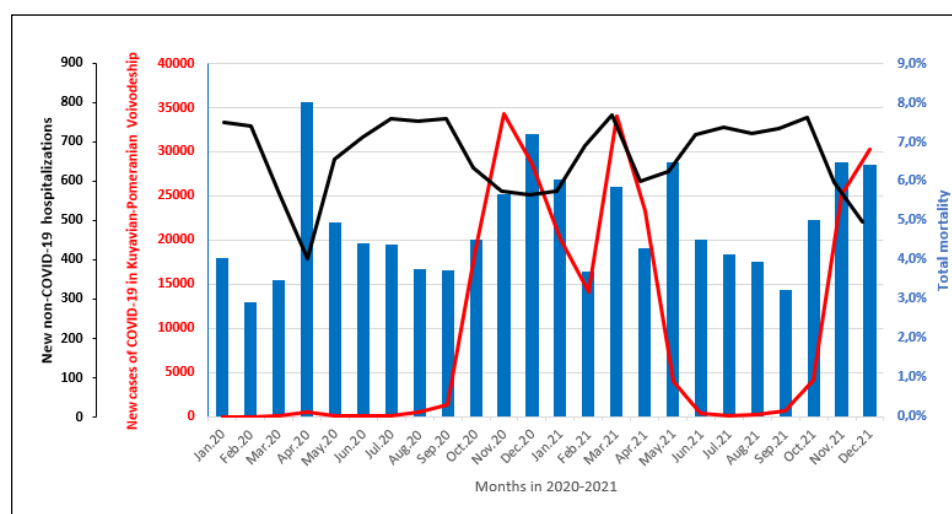


Figure 1. Total mortality in the selected departments correlated with the number of new COVID-19 infections in Kuyavian-Pomeranian Voivodeship on a monthly basis in 2020–2021. New non-COVID-19 hospitalizations are shown in the background

Discussion

The analysis of Antoni Jurasz University Hospital No. 1 in the Bydgoszcz database, particularly in terms of non-COVID-19 patients, yielded significant findings regarding hospital functioning during the pandemic. Selected departments noted increased in-hospital mortality and decreased the number of hospitalizations as well as a significant impact on the length of stay for hospitalizations. The changes correlated with new monthly COVID-19 cases in the region. To the best of the authors' knowledge, this is the first study to investigate the impact of the COVID-19 pandemic on an entire hospital and on all its departments individually.

The reduction in hospital admissions of non-COVID-19 patients was also observed in hospital depart-

ments in other countries, that is in the UK [5], the USA [6], Italy [7], and Australia [8]. In Poland, in 24 Cardiology Departments, the total number of hospitalizations in 2020 decreased by 28.6% compared to the year before [9]. The reduction in hospital admissions happened regardless of department size [10]. This trend can be ascribed not only to public sentiment associated with the pandemic but also to governmental regulations. To minimize the risk of COVID-19 infection, on March 15, 2020, the Polish National Health Fund (NFZ, *Narodowy Fundusz Zdrowia*) issued recommendations to reduce to the necessary minimum or temporarily suspend the provision of scheduled and elective services; however, some medical services could have been provided via communication and information systems [11]. Nevertheless, the Supreme Audit Office (NIK, *Najwyższa*

Table 5. Mortality in the selected departments with a distinction between prespecified subperiods: period 1a: 01.2020–08.2020; period 2a: 09.2020–05.2021; period 1b: 06.2021–09.2021; period 2b: 10.2021–12.2021

Department	Period 1a			Period 2a			Period 1b			Period 2b			p-value
	Survival	Deaths	Mortality	Survival	Deaths	Mortality	Survival	Deaths	Mortality	Survival	Deaths	Mortality	
Department of Anaesthesiology and Intensive Care with a Subdivision of Cardioanaesthesiology	492	16	3.1%	524	17	3.1%	261	4	1.5%	175	7	3.8%	0.46117
Department of Anaesthesiology and Intensive Therapy	391	97	19.9%	317	87	21.5%	160	47	22.7%	97	37	27.6%	0.27984
Department of Vascular Surgery and Angiology	837	12	1.4%	872	19	2.1%	477	2	0.4%	392	11	3.2%	0.01360
Department of Cardiology	2547	91	3.4%	2816	157	5.3%	1467	54	3.6%	956	43	4.3%	0.00323
Department of Neurosurgery, Neurotraumatology and Paediatric Neurosurgery	951	17	1.8%	1061	26	2.4%	497	10	2.0%	214	12	5.3%	0.01466
Summary	5218	233	4.3%	5590	306	5.2%	2862	117	3.9%	1774	110	5.8%	0.0021

Izba Kontroli), conducting inspections in medical facilities throughout Poland between January 2020 and May 2021, concluded that some of the hospitals were ineffective in the management of available beds for COVID-19 patients, which could have led to limiting the access to hospital care for non-COVID-19 patients [12].

The length of stay can be a very important indicator of effective hospital management and quality of patient care. The shorter the length of hospital stay, the greater the availability of beds for patients and the lower the consumption of hospital resources. Reduced duration of hospitalization is associated with a lower risk of opportunistic infections as well as lower mortality rates [13]. In the present analysis, selected departments managed to reduce the average length of hospitalization. On the other hand, in the case of the Department of Anaesthesiology and Intensive Care with a Subdivision of Cardioanaesthesiology (department 1), an increased average length of hospitalization correlating with new monthly COVID-19 cases in Kuyavian-Pomeranian Voivodeship co-occurred with the increase in mortality rates, with a potential cause-and-effect relationship. The longer average hospitalization length in the Department of Geriatrics (department 8) could have resulted in lower availability of beds for patients, potentially leading to a reduced number of hospitalizations in this department. It can be speculated that the decrease in mortality rate in the Department of Endocrinology and Diabetology (department 7), which correlated with new monthly COVID-19 cases in the region, could be explained by shorter hospitalization length and lower number of hospitalized patients in this department.

In-hospital mortality rates in selected departments were higher when the monthly number of new COVID-19 infections exceeded 1000. The highest in-hospital mortality was recorded in period 2b, i.e. October 2021 — December 2021. The Department of Anaesthesiology and Intensive Therapy (department 2) had the highest mortality of 34.8%, which was recorded in November 2021. Several studies have been conducted to investigate the impact of the COVID-19 pandemic on non-COVID-19 hospitalized patients' mortality. A study by Boyer et al. [14] investigated non-COVID-19-related acute hospitalizations of patients with schizophrenia and patients without mental disorders in the pre-COVID-19 and COVID-19 periods in France. The 90-day hospital mortality in schizophrenic patients increased significantly more than in the control group. Authors suggested that the quality and safety of patient care as well as its accessibility were the factors contributing to this increase in mortality. In a post hoc analysis of the SepsisDataNet.NRW study [15] conducted in Germany, non-COVID-19 sepsis patients admitted before and during the pandemic were compared. A significant increase in raw 30-day mortality was noted in the group admitted to hospitals during the pandemic

(33% vs. 52%, $p = 0.004$). However, a notable difference in the severity of the disease on admission was also found. When adjusted for this finding, the mortality rates were 52% in both groups. This may be due to difficult access to medical care and delayed hospital admission during the pandemic. In terms of the proper functioning of health services during the pandemic, the role of healthcare workers cannot be overstated. It has been proven that exposure of severely ill patients to medical personnel with a heavy workload reduces the chances of survival [16]. On that matter, a study by Grzelakowska et al. [17] conducted in Poland, at Antoni Jurasz University Hospital No. 1 in Bydgoszcz, explored how the COVID-19 pandemic affected the healthcare workers of this facility. The medical personnel was a significantly affected group, which could have been observed through higher rates of infections and quarantines, especially among nurses and doctors. The study showed that COVID-19 had both direct and indirect impacts on the availability of healthcare workers through infections, quarantine, and sick leave, undoubtedly affecting hospitals' resources.

The limitation of this study was the influence of state administration (Ministry of Health and provincial governor Voivode) on the functioning rules of the hospital. The organizational changes made by the Antoni Jurasz University Hospital No. 1 in Bydgoszcz during the pandemic were oftentimes not dictated by considerations of the facility's current epidemiological condition but rather were mandatory government-enforced regulations. It is also important to note that this analysis focuses on the influence of COVID-19 on the hospital within two years. It is fundamental to investigate the long-term impact of the pandemic on hospital functioning and clinical outcomes in the future.

Conclusions

The analysis of the two years of the COVID-19 pandemic in Antoni Jurasz University Hospital No. 1 in Bydgoszcz, Poland, found in selected departments a significantly increased in-hospital mortality, decreased the number of hospitalizations and decreased length of stay. Departments exhibiting an opposite impact of the pandemic on the average length of hospitalization were identified. The changes correlated with new monthly COVID-19 cases in the region.

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