Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

COVID-19 shock and recovery trajectories in hospital care across regions in Poland, 2018-2024: the role of day-care capacity in health-system resilience

Krystian Małyszko

krystian.malyszko@sd.umb.edu.pl

Marshal's Office of the Podlaskie Voivodeship

Bartosz Pędziński

Lomza Medical Center Ltd.

Marcin Warpechowski

Medical University of Bialystok

Dominik Maślach

Podlaskie Voivodeship Office

Ludmiła Marcinowicz

Medical University of Bialystok

Research Article

Keywords: health services research, health system resilience, hospital care, service delivery, regional variation, day-care services, Poland

Posted Date: May 15th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9331640/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Abstract

Background

COVID-19 caused a marked contraction in non-COVID hospital activity and a prolonged, uneven recovery. Evidence on multi-year regional recovery patterns and the system capacities that may support resilience remains limited.

Methods

We conducted an observational panel study using aggregated administrative data for Poland's 16 voivodeships from 2018 to 2024. Data were obtained from the Statistical Bulletins of the Polish Ministry of Health prepared by the e-Health Centre. Hospitalisations were indexed to 2019 (2019 = 100). We first described regional shock and recovery patterns. We then estimated an event-study model with voivodeship and year fixed effects, interacting year indicators with standardized pre-pandemic day-care availability, measured as the 2018–2019 average number of day-care places per 100,000 population.

Results

Nationally, the hospitalisation index fell to 78.5 in 2020 and recovered gradually to 102.4 by 2024. Recovery trajectories differed substantially across voivodeships: the 2020 decline ranged from about −29% to -12%, and the 2024 index ranged from below 90 to above 120. Higher pre-pandemic day-care availability was associated with a more favourable mid-recovery trajectory. A one-standard-deviation higher day-care availability was associated with a 2.94-point higher hospitalisation index in 2022 (95% CI 0.55 to 5.32) and a 2.61-point higher index in 2023 (95% CI 0.86 to 4.35). Associations in 2020–2021 were positive but imprecise, and the association attenuated in 2024.

Conclusions

Greater pre-pandemic day-care capacity was associated with stronger mid-term recovery of hospital care after the COVID-19 shock. The findings suggest that alternative-care capacity may function as an adaptive resource during recovery from major disruptions. Strengthening day-care services and aligning financing to support substitution away from full inpatient care may improve hospital-sector resilience and support faster recovery after future shocks.

Research in Context

What is already known about the topic?

The COVID-19 pandemic caused a substantial decline in hospital activity across countries, followed by a prolonged and uneven recovery. Previous studies have documented reductions in hospital admissions and elective procedures, but evidence on longer-term recovery trajectories and the system-level capacities that support resilience remains limited.

What does this study add to the literature?

This study provides a multi-year regional analysis of hospital care in Poland from 2018 to 2024, showing marked heterogeneity in both the depth of the pandemic shock and the pace of recovery across voivodeships. It shows that higher pre-pandemic availability of day-care services was associated with a more favourable recovery trajectory of hospitalisations in the mid-recovery phase, suggesting that alternative-care capacity may operate as an adaptive health-system resource.

What are the policy implications?

Developing day-care and other alternatives to full inpatient care may improve both efficiency and resilience. Policymakers should consider monitoring alternative-care capacity as part of preparedness and recovery planning, and should align financing and contracting arrangements to support appropriate substitution away from inpatient care, especially in regions with weaker recovery.

Background

The COVID-19 pandemic placed European health systems under an acute and sustained stress test. Across countries, non-COVID hospital activity fell sharply, elective care was deferred, and backlogs accumulated well beyond the initial emergency period [1–4]. This experience has intensified interest in health-system resilience, understood not only as the capacity to absorb a shock, but also to maintain core functions, adapt service delivery, and recover activity over time [5].

Poland offers a relevant setting for studying these issues. The hospital sector operates under a common national institutional and financing framework, yet important inter-voivodeship differences persist in resources, organization of care, and the ability to reconfigure service delivery [6–15]. This makes regional comparison analytically useful: variation in recovery trajectories can be examined within one policy environment, reducing the likelihood that differences are driven only by fundamentally different financing rules or governance models.

The question is important for health services research and policy. Much of the pandemic literature focused on the immediate decline in admissions or on selected specialties, while fewer studies have examined multi-year recovery and the service-delivery capacities that may support it [16–18]. In particular, resources that enable substitution away from full inpatient stays, such as day-care or day-case services, may increase operational flexibility by reducing pressure on beds and staffing while helping systems restore throughput during backlog clearance [19–20].

A regional perspective also has practical relevance beyond routine performance monitoring. Some Polish regions, especially on the eastern flank, face additional preparedness demands related to cross-border pressures, migration, and wider security risks [21–23]. For these systems, the ability to sustain and recover hospital activity after a major disruption is not only a matter of efficiency, but also of strategic resilience.

In this study, we analyse hospital care across Poland's 16 voivodeships between 2018 and 2024 using a shock-recovery lens. First, we describe the scale of the 2020 contraction in hospitalisations and the pace of recovery through 2024, highlighting regional heterogeneity. Second, we test whether higher pre-pandemic availability of day-care services was associated with a more favourable post-shock recovery trajectory, using an event-study model with voivodeship and year fixed effects [24].

Methods

Study design and setting

We conducted an observational panel study using aggregated administrative data at the voivodeship-year level. The unit of analysis was the voivodeship (N = 16), and the analytic period covered 2018–2024. The study had two objectives: (1) to describe the magnitude of the COVID-19 shock to hospital care in 2020 and the subsequent recovery in 2021–2024; and (2) to assess whether regional differences in recovery were associated with pre-pandemic availability of day-care services.

Data sources

Data were obtained from the Statistical Bulletins of the Polish Ministry of Health prepared by the e-Health Centre (Centrum e-Zdrowia). The hospital-care section of the Bulletins is based on routine ministerial reporting, including the MZ-29 report on hospital activity, resources, and day-care services. Population denominators were taken as the voivodeship population as of 31 December of each year and were used to calculate per-capita indicators. Details on harmonisation across Bulletin editions and handling of missing values are provided in Additional file 1.

Variables

Hospitalisations were defined as the number of patients treated during the year in general inpatient hospitals. The primary outcome was the hospitalisation index for voivodeship i in year t, expressed relative to 2019 (2019 = 100). The COVID-19 shock was operationalised descriptively as the percentage change in hospitalisations in 2020 relative to 2019, while recovery was assessed descriptively using the hospitalisation index in 2024.

The key explanatory variable was pre-pandemic availability of day-care services, measured as the number of day-care places per 100,000 population. To capture baseline capacity before the pandemic,

this measure was averaged over 2018–2019 and standardised to one standard deviation across voivodeships.

Statistical analysis

We first described national and regional trends in hospitalisations and ranked voivodeships by the size of the 2020 shock and the level of recovery in 2024. We then estimated an event-study model with voivodeship and year fixed effects to assess whether pre-pandemic day-care availability was associated with differential recovery trajectories after 2020. The model regressed the hospitalisation index on interactions between standardised pre-pandemic day-care availability and year indicators, using 2019 as the reference year.

Coefficients were interpreted as differences in the hospitalisation index associated with a one-standard-deviation higher pre-pandemic day-care availability. Standard errors were clustered at the voivodeship level. As a sensitivity analysis, heteroskedasticity-robust (HC1) standard errors were also estimated and are reported in Additional file 1. Analyses were conducted in R version 4.5.2.

Use of generative AI in manuscript preparation

ChatGPT (OpenAI) was used to support language editing and improve clarity and readability during manuscript preparation. All substantive scientific content, interpretation, and final wording were reviewed and approved by the authors. No generative AI tools were used to generate data, perform statistical analyses, or draw scientific conclusions.

Results

National shock and recovery trajectory

Across Poland, hospital activity was slightly higher in 2018 than in 2019, followed by a pronounced contraction in 2020. The mean hospitalisation index fell to 78.5 in the shock year and then recovered gradually, reaching 102.4 by 2024 (Fig. 1). This rebound was not accompanied by evidence of recovery through longer inpatient stays: average length of stay changed only marginally in 2020 and was shorter in 2024 than in 2019, while bed occupancy returned close to its pre-pandemic level.

Regional heterogeneity in shock magnitude and recovery

Substantial heterogeneity was observed across voivodeships in both the depth of the 2020 contraction and the level of recovery in 2024 (Fig. 2; Additional file 1: Table S3). The decline in hospitalisations in 2020 ranged from approximately – 28.7% to -12.2%, while the hospitalisation index in 2024 ranged from 89.8 to 123.7. Regions that experienced deeper initial declines did not necessarily have weaker

subsequent recovery, suggesting that post-shock trajectories were shaped by regional system characteristics rather than by initial shock depth alone.

Voivodeships on Poland's eastern flank showed, on average, a slightly smaller decline in 2020 but also a lower mean recovery level in 2024 than other regions. This pattern is descriptive and should be interpreted cautiously given the small number of regions.

Association between day-care availability and recovery

Results from the event-study model are shown in Fig. 3 and Table 1. Higher pre-pandemic availability of day-care services was associated with a more favourable recovery trajectory after 2020. The association was strongest in the mid-recovery phase. In 2022, a one-standard-deviation higher day-care availability was associated with a 2.94-point higher hospitalisation index (95% CI 0.55 to 5.32), and in 2023 with a 2.61-point higher index (95% CI 0.86 to 4.35).

Table 1
Event-study model results for pre-pandemic day-care availability (1 SD, pre-shock).

Year	Coefficient (SE) - clustered	95% CI - clustered	Coefficient (SE) - HC1
2018	3.61 (2.63)	-1.55 to 8.77	3.61 (2.13)
2020	1.87 (1.35)	-0.77 to 4.52	1.87 (1.54)
2021	2.20 (1.50)	-0.73 to 5.14	2.20 (1.36)
2022	2.94 (1.22)	0.55 to 5.32	2.94 (1.26)
2023	2.61 (0.89)	0.86 to 4.35	2.61 (1.31)
2024	0.25 (1.82)	-3.32 to 3.81	0.25 (1.93)

Note: Outcome is the hospitalisation index (2019 = 100). The model includes voivodeship and year fixed effects; 2019 is the reference year. Main inferences are based on standard errors clustered by voivodeship; HC1 estimates are reported as a sensitivity analysis.

In 2020 and 2021, estimates were positive but imprecise, with confidence intervals crossing zero. By 2024, the coefficient attenuated and was no longer statistically significant. Estimates based on HC1 standard errors showed the same overall pattern (Additional file 1).

Discussion

This study shows that the COVID-19 shock to hospital care in Poland was deep, prolonged, and regionally uneven. The national hospitalisation index fell to 78.5 in 2020 and recovered only gradually, exceeding the 2019 reference level in 2024. At the same time, voivodeships differed substantially both in the size of the initial contraction and in the strength of their rebound. For health services research, this

matters because it shifts attention from the shock itself to the service-delivery capacities that may help systems restore activity after disruption.

The main analytical finding is that regions with higher pre-pandemic day-care availability experienced a more favourable recovery trajectory in 2022–2023. This is consistent with an interpretation of day-care capacity as part of health-system resilience: a resource that may increase flexibility, support backlog clearance, and reduce dependence on bed-intensive inpatient pathways during recovery. The fact that recovery was not accompanied by longer average length of stay further supports the view that the rebound reflected restored throughput rather than simple prolongation of inpatient episodes.

The findings fit a broader resilience literature that emphasizes adaptation, reconfiguration, and recovery over time rather than short-term crisis response alone [25–26]. They also align with work showing that post-pandemic restoration of activity has depended on organizational capacity, local context, and the ability to shift care toward less resource-intensive settings [25–35]. In this sense, day-care services may be relevant not only as an efficiency strategy, but also as an operational buffer that helps systems maintain service delivery under strain and accelerate recovery when routine activity resumes.

The policy relevance is direct. First, indicators of alternative-care capacity, including day-care availability and utilisation, may deserve a more prominent place in routine monitoring of hospital-system preparedness and recovery, alongside conventional indicators such as beds, occupancy, and length of stay. Second, resilience-enhancing capacity is unlikely to develop automatically unless payment and contracting arrangements support substitution away from full inpatient care. If providers are financially penalized for shorter or less bed-intensive treatment pathways, the system may underinvest in precisely the forms of care that increase adaptability after shocks. Third, the marked regional heterogeneity suggests that recovery policy should not rely exclusively on national averages. Regions with persistently weaker rebound may need targeted planning support, especially where broader demographic, migration-related, or security pressures place additional demands on hospital capacity.

The study also has an international message. Although the institutional context is Polish, the underlying problem is not country-specific. Many health systems are still confronting how to manage backlogs, redesign hospital pathways, and improve preparedness for future shocks. The present results contribute to that discussion by suggesting that pre-existing service configuration - specifically the availability of alternatives to conventional inpatient care - may shape how quickly hospital activity can be rebuilt after disruption.

Several limitations should be acknowledged. First, this is an ecological study at the voivodeship level, so the analysis cannot identify patient-level or hospital-level mechanisms and is subject to ecological fallacy [35]. Second, the small number of regions limits statistical power and calls for cautious interpretation of effect sizes. Third, as in other event-study and difference-in-differences style analyses, the estimates may be influenced by unobserved time-varying regional factors, including case mix, provider composition, local epidemic burden, and managerial responses not captured in the model.

Finally, the hospitalisation index measures volume rather than appropriateness, complexity, or quality of care.

These limitations do not negate the contribution of the study, but they define its scope. Future work should test the proposed mechanisms using provider-level or patient-level data, examine specialty-specific patterns, and evaluate whether financing and regulatory instruments for day-care care modify recovery speed. Overall, the results support the view that day-care capacity may function as a practical component of hospital-system resilience during the recovery phase after major shocks.

Conclusions

Across Poland's 16 voivodeships, the COVID-19 pandemic was followed by a marked decline in hospitalisations in 2020 and an uneven multi-year recovery through 2024. Higher pre-pandemic availability of day-care services was associated with a more favourable mid-term recovery trajectory. Strengthening alternative-care capacity and aligning financing to support substitution away from full inpatient care may help health systems recover faster from future disruptions and improve the resilience of hospital service delivery.

Abbreviations

ALOS
Average length of stay
CI
Confidence interval
HC1
Heteroskedasticity-robust standard errors
NATO
North Atlantic Treaty Organization
SD
Standard deviation

Declarations

Ethics approval and consent to participate

The study used aggregated administrative data at the voivodeship level and did not include personal or identifiable information. Formal ethical approval and informed consent to participate were therefore not required under applicable local regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author Contribution

K.M. conceived the study, designed the study, curated the data, led the interpretation of the findings, and wrote the first and subsequent drafts of the manuscript. B.P. contributed to study design, interpretation of the results, and critical revision of the manuscript. L.M. supervised the work, contributed to interpretation of the results, and critically revised the manuscript. M.W. reviewed and validated the statistical analysis and critically revised the manuscript. D.M. reviewed the manuscript and contributed to critical revision. All authors approved the final version and agreed to be accountable for all aspects of the work.

Acknowledgements

Not applicable.

Data Availability

The study used aggregated administrative data extracted from annual Statistical Bulletins of the Polish Ministry of Health prepared by the e-Health Centre (Centrum e-Zdrowia). The source bulletins are publicly available.

References

1. Haldane V, De Foo C, Abdalla SM, et al. Health systems resilience in managing the COVID-19 pandemic: lessons from 28 countries. Nat Med. 2021;27:964–80. 10.1038/s41591-021-01381-y.
2. Moynihan R, Sanders S, Michaleff ZA, et al. Impact of COVID-19 pandemic on utilisation of healthcare services: a systematic review. BMJ Open. 2021;11:e045343. 10.1136/bmjopen-2020-045343.
3. Bodilsen J, Nielsen PB, Sogaard M, et al. Hospital admission and mortality rates for non-COVID diseases in Denmark during COVID-19 pandemic: nationwide population based cohort study. BMJ. 2021;373:n1135. 10.1136/bmj.n1135.

4. COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. Br J Surg. 2020;107:1440–9. 10.1002/bjs.11746.
5. Kruk ME, Myers M, Varpilah ST, Dahn BT. What is a resilient health system? Lessons from Ebola. Lancet. 2015;385(9980):1910–2. 10.1016/S0140-6736(15)60755-3.
6. Malyszko K, Pedzinski B, Maslach D, Krzyzak M, Marcinowicz L. Medical staff in Poland in 2012–2022 - challenges related to the distribution of human resources. Ann Agric Environ Med. 2024. 10.26444/aaem/186636.
7. Domagala A. Planning of Polish physician workforce - Systemic inconsistencies, challenges and possible ways forward. Health Policy. 2018;122(2):102–8. 10.1016/j.healthpol.2017.11.013.
8. Dubas-Jakobczyk K, Domagala A, Mikos M. Impact of the doctor deficit on hospital management in Poland: A mixed-method study. Int J Health Plann Manage. 2019;34(1):187–95. 10.1002/hpm.2612.
9. Sowada C, Kowalska-Bobko I, Sagan A. What next after the 'commercialization' of public hospitals? Searching for effective solutions to achieve financial stability of the hospital sector in Poland. Health Policy. 2020;124(10):1050–5. 10.1016/j.healthpol.2020.05.024.
10. Dubas-Jakobczyk K, Kocot E, Koziel A. Financial performance of public hospitals: A cross-sectional study among Polish providers. Int J Environ Res Public Health. 2020;17(7):2188. 10.3390/ijerph17072188.
11. Dubas-Jakobczyk K, Kowalska-Bobko I, Sowada C. The 2017 reform of the hospital sector in Poland - The challenge of consistent design. Health Policy. 2019. 10.1016/j.healthpol.2019.03.013.
12. OECD/European Observatory on Health Systems and Policies. State of Health in the EU: Country Health Profile 2025 - Poland. Paris: OECD Publishing; 2025.
13. Sagan A, Kowalska-Bobko I, Badora-Musial K, Galazka-Sobotka M. A reform proposal from 2019 aims to improve coordination of health services in Poland by strengthening the role of the counties. Health Policy. 2022;126(9):837–43. 10.1016/j.healthpol.2022.06.006.
14. Sowada C, Sagan A, Kowalska-Bobko I et al. Poland: Health system review. Health Syst Transit. 2019;21(1).
15. Sliwczynski A, Drobnik J, et al. Dynamics of inpatient care in Poland during the COVID-19 pandemic. Sci Rep. 2024;14:62671. 10.1038/s41598-024-62671-2.
16. Bosque-Mercader L, Conroy S, Lasserson D, Mannion R, Nicodemo C, Wittenberg R. Resilience of the acute sector in recovery from COVID-19 pressures. Soc Sci Med. 2025;375:118062. 10.1016/j.socscimed.2025.118062.
17. Aldridge S, Schmidt A, Thißen M, et al. Has the COVID-19 pandemic changed existing patterns of non-COVID-19 health care utilization? A retrospective analysis of six regions in Europe. Eur J Public Health. 2024;34(Suppl 1):i67–73. 10.1093/eurpub/ckad180.
18. Shah Z, Maddock J, Croker R, et al. Effect of the COVID-19 pandemic on NHS England waiting times: a modelling study. Lancet. 2024;403:613–4. 10.1016/S0140-6736(23)02744-7.

19. Baumann A, Wyss K. The shift from inpatient to outpatient care in Switzerland since 2017: Policy processes and role of evidence. Health Policy. 2021;125:512–9. 10.1016/j.healthpol.2021.01.012.
20. Brungger B, Boni C, Zimmermann H, et al. Inpatient vs outpatient settings and follow-up costs after elective surgery: a propensity score-matched analysis. Health Policy. 2021;125(9):1237–44. 10.1016/j.healthpol.2021.07.012.
21. Spiegel PB. Are the health systems of EU countries hosting Ukrainian refugees ready to adapt? Lancet Healthy Longev. 2022;3(10):e639. 10.1016/S2666-7568(22)00187-8.
22. Bielefeld M, et al. Health system response to the war and displacement crises in Europe. Lancet Reg Health Eur. 2024;47:101122. 10.1016/j.lanepe.2024.101122.
23. Naumann DN, Riches S, O'Brien P, et al. Research in health-care resilience for large-scale conflict, disasters and mass casualty events. Lancet. 2025;406:2749–50. 10.1016/S0140-6736(25)02354-2.
24. Wang G, Hamad R, White JS. Advanced DiD methods for policy evaluation research. Epidemiology. 2024;35(5):628–34. 10.1097/EDE.0000000000001755.
25. Blanchet K, Nam SL, Ramalingam B, Pozo-Martin F. Governance and capacity to manage resilience of health systems: towards a new conceptual framework. Int J Health Policy Manag. 2017;6(8):431–5. 10.15171/ijhpm.2017.36.
26. Witter S, Hirschhorn LR, Rao KD, et al. Health system resilience: a critical review and reconceptualisation. Lancet Glob Health. 2023;11:e1454–8. 10.1016/S2214-109X(23)00279-6.
27. Chen LW, Salas ME, Branch-Elliman W, et al. Inpatient-to-outpatient shifts in surgical care: persistence of COVID-19-era changes and socioeconomic heterogeneity. Med Care Res Rev. 2025. 10.1177/10775587251396718.
28. Pell JM, et al. Impact of the first UK COVID-19 lockdown on hospital admissions: interrupted time series analysis of 32 million admissions. EClinicalMedicine. 2022;49:101462. 10.1016/j.eclinm.2022.101462.
29. Akobirshoev I, Vetter M, Iezzoni LI, Rao SR, Mitra M. Delayed medical care and unmet care needs due to the COVID-19 pandemic among adults with disabilities in the US. Health Aff (Millwood). 2022;41(10):1505–12. 10.1377/hlthaff.2022.00509.
30. Pugh J, Seah M, Carr A, Savulescu J. Tackling the COVID elective surgical backlog: Prioritising need, benefit or equality? Clin Ethics. 2023;18. 10.1177/14777509231166532.
31. Bosa I, Castelli A, Castelli M, et al. Corona-regionalism? Differences in regional responses to COVID-19 in Italy. Health Policy. 2021;125(11):1179–87. 10.1016/j.healthpol.2021.06.004.
32. Ayyaz M, et al. Association of day case rates with elective surgical activity recovery in England following COVID-19 disruption: a national-level analysis. Ann R Coll Surg Engl. 2025;107(3):172–8. 10.1308/rcsann.2023.0111.
33. Ponusz R, Endrei D, Kovacs D, et al. The development of one-day surgical care in Hungary between 2010 and 2019. BMC Health Serv Res. 2022;22:798. 10.1186/s12913-022-08102-2.

34. Kreutzberg A, Eckhardt H, Milstein R, Busse R. International strategies, experiences, and payment models to incentivise day surgery. Health Policy. 2024;140:104968. 10.1016/j.healthpol.2023.104968.
35. Pearce N. The ecological fallacy strikes back. J Epidemiol Community Health. 2000;54:326–7. 10.1136/jech.54.5.326.

Figures

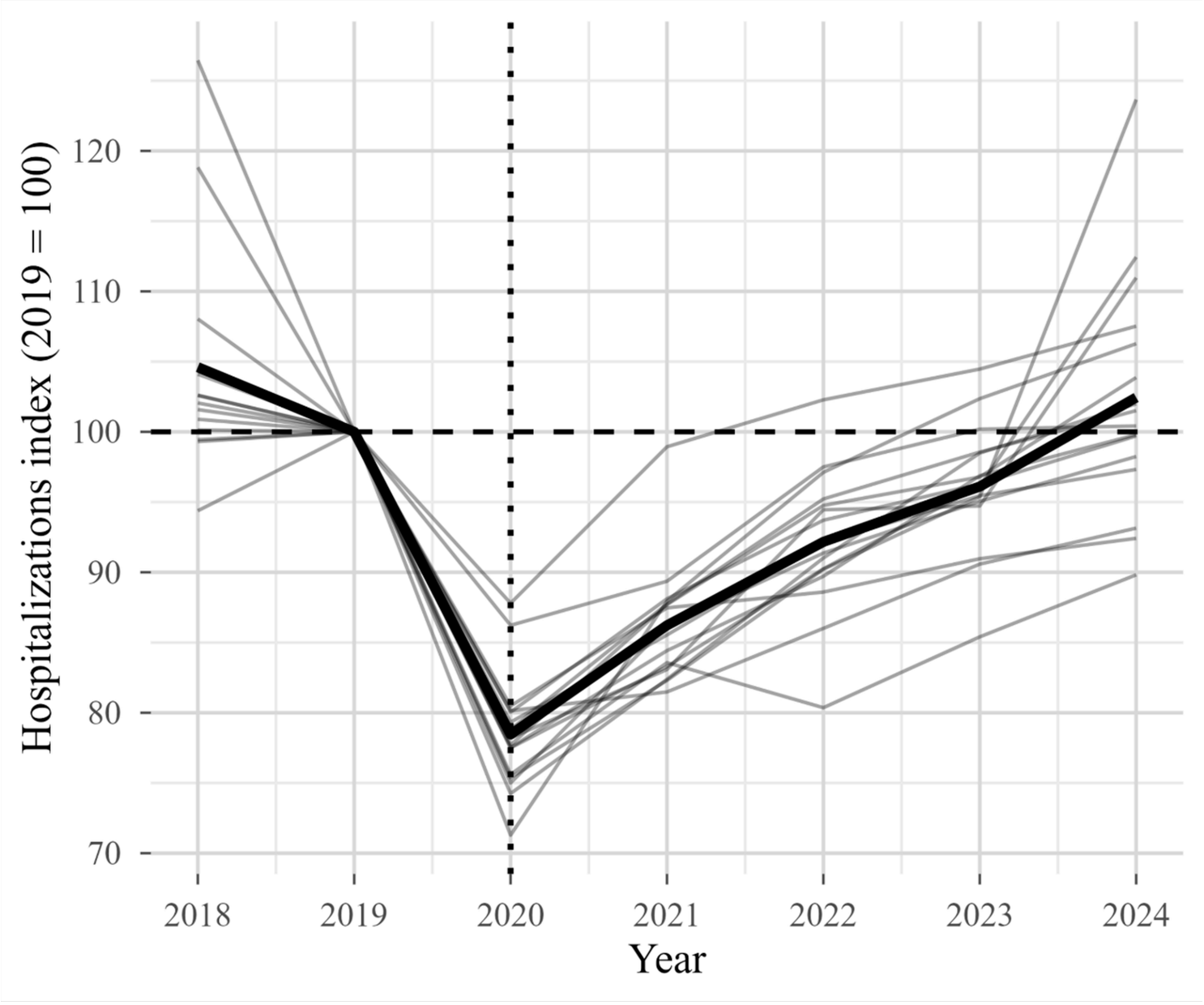


Figure 1

Hospitalisation index across Polish voivodeships, 2018-2024 (2019 = 100). Grey lines represent individual voivodeships and the black line represents the national mean. The vertical dashed line marks 2020 as the pandemic shock year; the horizontal dashed line indicates the 2019 reference level.

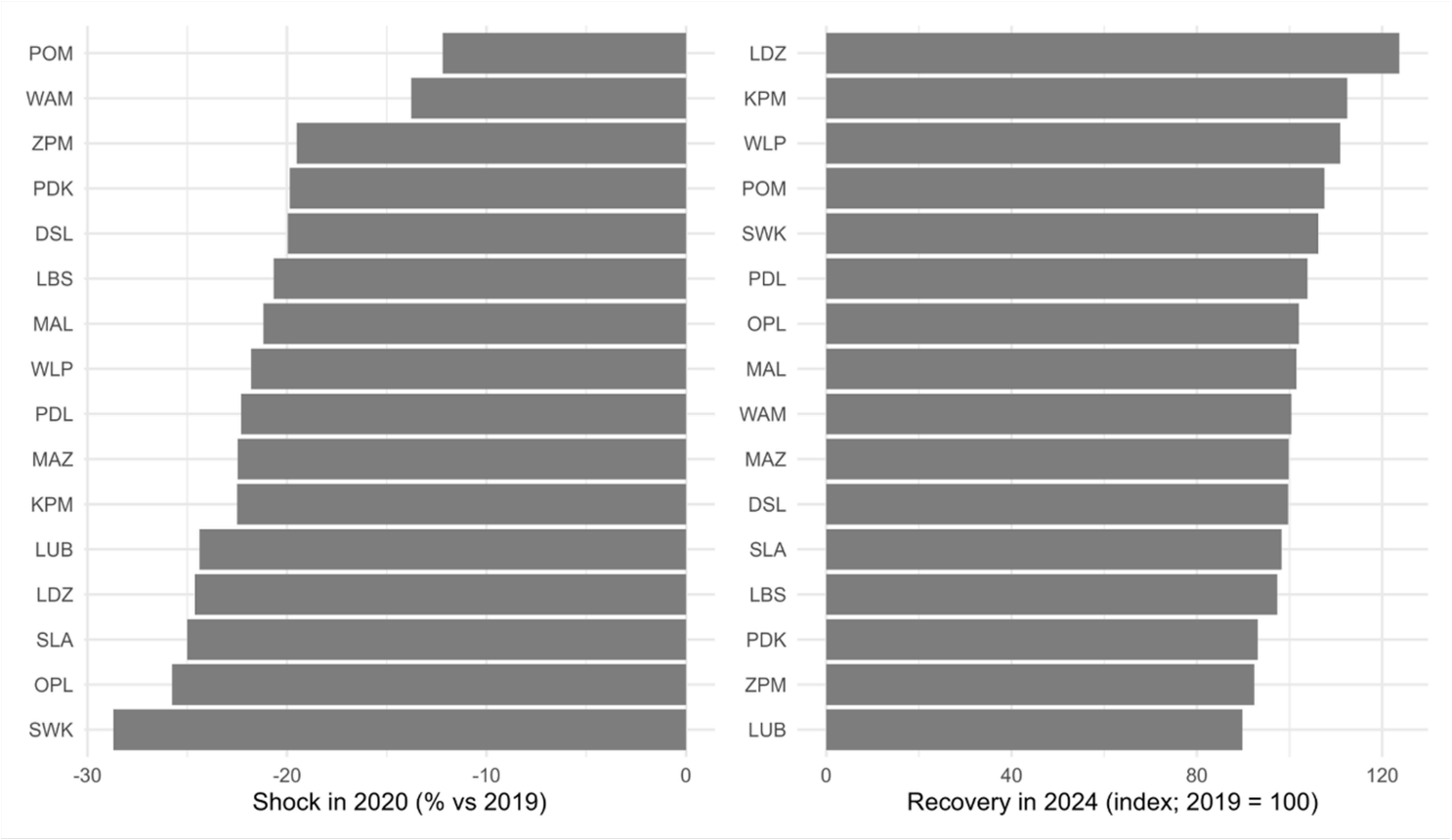


Figure 2

Regional heterogeneity in the COVID-19 shock and subsequent recovery of hospital care. The left panel ranks voivodeships by the percentage change in hospitalisations in 2020 relative to 2019. The right panel ranks voivodeships by the hospitalisation index in 2024 (2019 = 100). Abbreviations are defined in Additional file 1: Table S2.

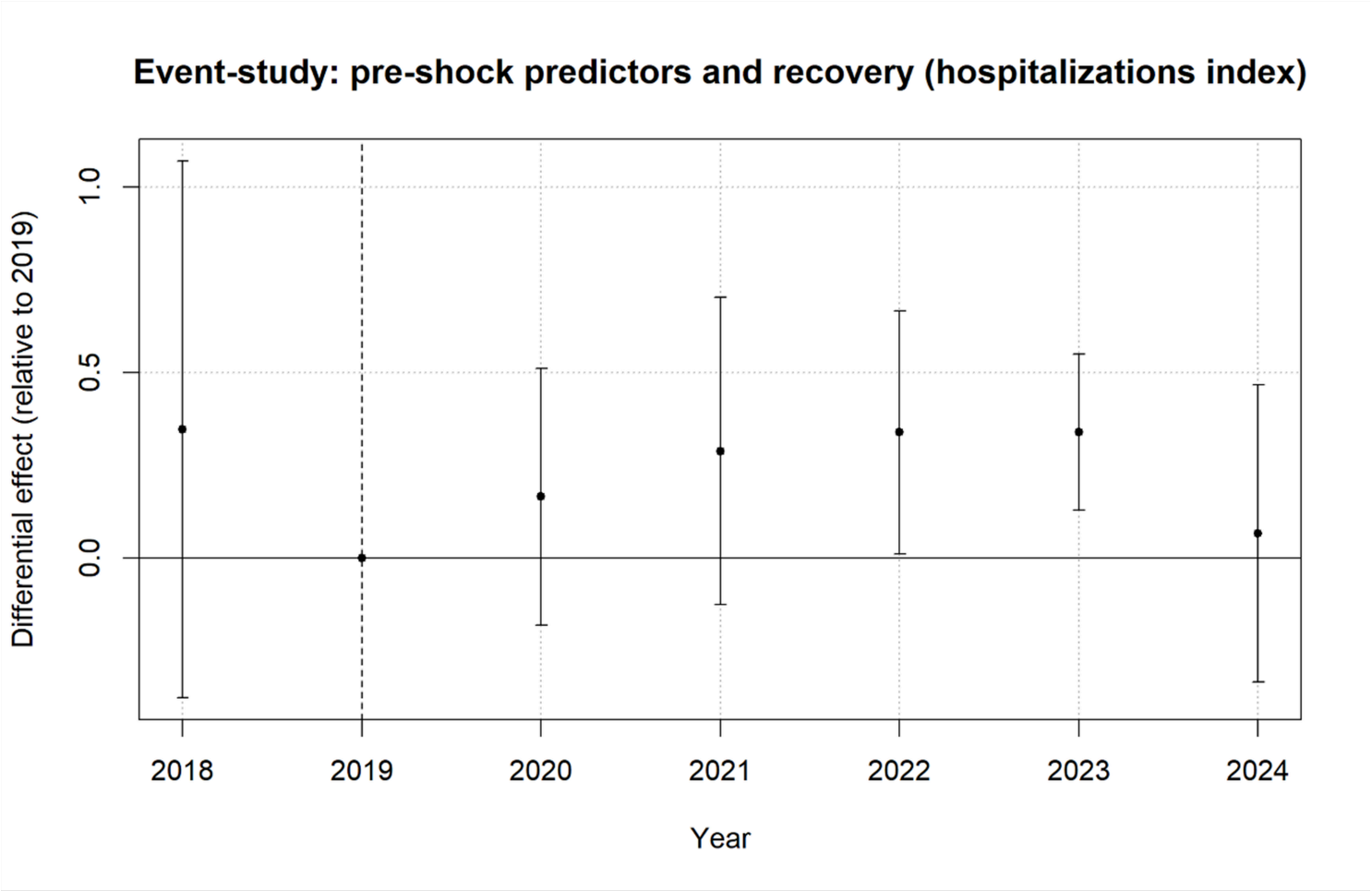


Figure 3

Event-study estimates for the association between pre-pandemic day-care availability and the recovery trajectory of hospitalisations. Points show year-specific coefficients for a one-standard-deviation increase in pre-pandemic day-care availability; whiskers indicate 95% confidence intervals. The 2019 coefficient is omitted as the reference year.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- AdditionalFile1SupplementaryMaterial.docx