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Indirect impact of the war in Ukraine on primary percutaneous coronary interventions for ST-elevation myocardial infarction in Poland

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What's New

This study, using the Polish data on ST-elevation myocardial infarction (STEMI) patients, sheds light on the indirect impacts of the war in Ukraine on a crucial aspect of healthcare such as the delivery of primary percutaneous coronary intervention (PCI). It shows that centers located within 100 km of the Polish-Ukraine border surpassed the expected volume of PCI procedures, while the centers situated over 100 km from the border maintained a consistent procedural rate, aligning closely with the predicted values. However, despite the observed fluctuations in PCI rates, the study found no discernible impact on adjusted fatality rate or quality of care outcomes based on the distance from the Polish-Ukraine border. The analysis outlines an importance of resilient healthcare system to meet the potential healthcare challenges in conflict zones and scenes of natural disasters.

Abstract

Introduction: The Russian invasion of Ukraine in February 2022 resulted in the displacement of approximately 12.5 million refugees to adjacent countries including Poland, that may have strained healthcare service delivery.

Objectives: Using the ST-elevation myocardial infarction (STEMI) data, we aimed to evaluate whether the Russian invasion of Ukraine has indirectly impacted the delivery of acute cardiovascular care in Poland.

Patients and Methods: We analyzed all adult patients undergoing percutaneous coronary interventions (PCI) for STEMI across Poland between 25th February 2017 to 24th May 2022. Centers were allocated to regions of <100km and >100km of the Polish-Ukraine border. Mixed effect generalized linear regression models with random effects per hospital were used to explore the associations between the war in Ukraine starting with several outcomes of interest, and whether these associations differed across regions of </>100km from the Polish-Ukraine border.

Results: A total of 90,115 procedures were included in the analysis. The average number of procedures per-month was similar to predicted volume for centers in the >100km region, while the average number of PCI was higher than expected (by an estimated 15 (11-19)) for the <100km region. There was no difference in adjusted fatality rate or quality of care outcomes pre- vs. during-war in both <100 and >100 km regions, with no evidence of a difference-in-difference across regions.

Conclusions: Following the Russian invasion of Ukraine, there was only a modest and temporary increase in primary PCI predominantly in centers situated within 100km of the border, although no significant impact on in-hospital fatality rate.

Key words

cardiovascular care, fatality rate, percutaneous coronary interventions, processes of care, ST-elevation myocardial infarction

Introduction

During periods of social and political instability caused by natural disasters, public health crises, and wars, healthcare delivery is frequently disrupted, affecting the quality of care and leading to poorer clinical outcomes. For instance, in the Coronavirus disease (COVID-19) pandemic, numerous countries implemented social containment mandates, commonly referred to as 'lockdowns,' to mitigate virus transmission. These measures may have unintentionally led to delays in patients seeking emergency care, resulting in a decline in cardiovascular admissions, notably for ST-elevation myocardial infarction (STEMI) [1-4]. The failure to promptly perform revascularization in patients presenting with STEMI is believed to have contributed to the increased deaths from acute coronary syndrome (ACS), heart failure, and out-of-hospital cardiac arrest observed in numerous healthcare systems during the pandemic [5-7]. In addition, the COVID-19 itself could influence the pathophysiology of ACS by increasing the risk for thromboembolic complications of ACS [8]. Similarly, natural disasters, such as Hurricane Katrina, have profoundly affected local healthcare, impacting not only acute illnesses [9] but also influencing future cardiovascular diseases [10] and the management of chronic conditions [11]. Similar observations have been documented following the Kobe earthquake in Japan [12].

On February 24, 2022, Russia's invasion of Ukraine triggered Europe's largest refugee crisis since World War 2, with an estimated 8 million people displaced within Ukraine by late May and 12.5 million Ukrainians crossing the border as of November 15, 2022 [13]. The majority of these refugees initially sought refuge in neighboring countries to the west of Ukraine, including Poland, Slovakia, Hungary, Romania, and Moldova, resulting in over 1.5 million refugees displaced into Poland [13]. Modelling estimates indicate that Ukrainian individuals may have comprised between 15% and 30% of the population in several major Polish cities near the border [14]. The impact of this unprecedented refugee displacement on healthcare delivery in Poland, particularly in cities closest to the Ukrainian border, remains unclear [15-17].

Using STEMI as a model for acute cardiovascular care delivery, our aim was to investigate how the Russian invasion of Ukraine has indirectly affected STEMI pathways, care delivery, and clinical outcomes in Poland. Furthermore, we explored whether this impact disproportionately affected the border regions closest to Ukraine, where the population displacement has been most significant.

Patients and Methods

Data Source and Study Population

We utilized data from the national registry of percutaneous coronary interventions (ORPKI), which is maintained by Jagiellonian University (Krakow, Poland) in collaboration with the Association of Cardiovascular Interventions (AISN) of the Polish Cardiac Society [18-22]. This study encompassed all adult patients (aged >18 years) who underwent a percutaneous coronary intervention (PCI) for STEMI in centers across Poland from February 25, 2017, to May 24, 2022. In the primary analysis, we excluded PCI cases that involved thrombolysis (Rescue PCI), constituting less than 0.5% of the data, as the primary focus of this analysis was on patients primarily treated with PCI. In a secondary analysis, such cases were included. Due to the nature of the data (registry of procedures), neither ethics committee approval nor written informed consent from patients was required.

Outcomes

The primary outcomes encompassed: (a) the number of cases presenting with ST-elevation myocardial infarction (STEMI) treated with percutaneous coronary intervention (PCI) and how this changed over time, (b) procedural fatality rate, and (c) the occurrence of procedural complications during the angiogram or PCI. Procedural complications were defined as a composite of events during the PCI procedure, including fatality rate, myocardial infarction (MI), no re-flow, bleeding at the puncture site, cardiac arrest, allergic reaction, coronary artery perforation during PCI, stroke during angiogram, or dissection during angiogram.

As secondary outcomes, assessing whether quality metrics of STEMI care were compromised involved consideration of the following: (i) prescription of a newer antiplatelet either pre-cath lab or during angiogram/PCI (i.e., the prescription of prasugrel or ticagrelor during pre-cath lab or angiogram/PCI, as opposed to the standard use of clopidogrel), (ii) the proportion of PCIs performed through radial access, and (iii) the use of intra-vascular imaging (IVUS or OCT). In the analysis of the prescription of a newer antiplatelet, patients not prescribed such medication were excluded, as the focus was on comparing the odds of prasugrel or ticagrelor prescription versus clopidogrel.

Time Periods and Centre Regions

We categorized time periods as before February 24, 2022 (Pre-War period) and after February 24, 2022 (During-War period) and classified centers based on their geographical distance from the Polish-Ukraine border. The distance from Polish-Ukrainian border was determined as the shortest road route from the closest Polish-Ukrainian border crossing. For the primary analysis, we defined regions as '<100km' vs. '>100km' from the border. As a sensitivity analysis, we considered regions of '<200km' and '>200km'. Centers within 100km of the border were deemed most likely to be affected by the refugee influx, but the impact could potentially extend further, hence the motivation for the sensitivity analysis.

Statistical Analysis

We summarized baseline characteristics as a whole cohort and by region, across pre-/during-war periods. Continuous variables were summarized using the mean and standard deviation and were compared using t-tests/ANOVA. Categorical variables were summarized using frequencies and were compared using chi-squared test.

Missing data in covariate information were imputed using multiple imputation, creating 20 imputed datasets [23]. Within the imputation models, we included all other variables, including the outcomes. Convergence of the imputation was confirmed. All the analyses outlined below were performed in each of the imputed datasets separately, before pooling the results using Rubin's rules [23].

We calculated the number of procedures per month, per region, across the study period. Given that the war in Ukraine started on 24th February 2022, we calculate each monthly procedure counts as being from 25th day of the previous month to the 24th day of current month. To these data, we fitted negative binomial models between 25th February 2017 and 24th December 2021, with covariates of; an indicator variable for region (<100km vs. >100km for main analysis, and <200km vs. >200km for sensitivity analysis), calendar time (both continuous and as a factor variable of month to capture seasonality), an indicator variable for COVID-19 (being 1 for 24th Feb 2020 onward, and 0 otherwise) and adjustment for the number of hospital sites per region. Using these models, we then predicted the expected number of procedures per-month-per-region, from 25th December 2021 until 24th May 2022. Predicted PCI volume was then compared to observed monthly volume.

Mixed effect logistic regression models with random effects per hospital were used to explore the associations between the war in Ukraine starting, and our patient-level outcomes of interest. All models included an indicator variable for region (<100km vs. >100km for main analysis, and <200km vs. >200km for sensitivity analysis), an indicator differentiating between observations prior to 24th February 2022 (Pre-War period) and after 24th February 2022 (During-War period), and the interaction between these variables. Time was included in the models as the number of months from 25th February 2017 (first day of dataset), along with an indicator variable for COVID-19 (being 1 for 24th Feb 2020 onward, and 0 otherwise). We also interacted time with region indicator to examine pre-war differences in the temporal changes in outcome. The models were adjusted for the variables listed in Supplementary material, *Table S1*, through a propensity score (propensity for region <100km vs. >100km). For each outcome, we calculated an odds ratio (OR) with 95% confidence interval (CI) comparing outcomes across pre-/during-war periods, by region (<100km vs. >100km), and then tested for interaction between region and period. See Supplementary material, *Supplementary Methods* for more details.

The measure of statistical significance was set to P <0.05. All analyses were undertaken in R version 4.2.0 [24], along with the “tidyverse” [25], “mice” and “lme4” packages [26].

Results

Of a total of 90,793 STEMI procedures that were included in the ORPKI registry within the study period, 9 were aged less than 18 years with a further 214 duplicate cases, all of which and were excluded. For the primary analysis, a further 455 procedures were excluded as they received thrombolysis during angiogram or PCI, giving 90,115 procedures included in this analysis. For the secondary analysis, thrombolysis cases were included, with a sample size of 90,570 procedures over the study period. The primary analysis dataset included a total of 162 hospitals, 8 of which were located <100km from the border.

Table 1 gives the baseline summary table of the primary analysis cohort, both overall and by region-time period combinations, with Supplementary material, *Table S2* giving that for the secondary analysis cohort that included thrombolysis cases. In the primary analysis cohort, the mean age of the study population was 65 years, with 68% being male. Overall, 17% had diabetes, with 31% being current or previous smokers and 12% had a prior history of PCI. 4.4% of the cohort presented with cardiac arrest at baseline. Of the whole cohort, 81% underwent the angiogram and PCI through radial access.

In general, we found that the baseline characteristics within each region were similar across time periods of pre- and during-war (Table 1, Supplementary material, *Tables S2-S4*). Some exceptions to this were that in centers >100km from the border, the proportion of cases with previous PCI, previous smoker and kidney disease were significantly different before and after 24th Feb 2022; such differences were not significant in <100km centers (Table 1). Interestingly, the proportion of direct transport cases for centers within 100km of border increased substantially during the war (from 22% of cases before 24th Feb 2022, to 41% after this date).

PCI Volume

Supplementary material, *Figure S1* shows the number of procedures per month for the whole cohort. We observed a steady decrease in the overall number of procedures through time, which became evident rapidly post COVID-19. Overall, there was little change upon the war starting in Ukraine, but this varied across region groups. Specifically, when comparing the predicted monthly volume per region (based on historic trends) to the observed monthly volume per region, the observed average number of procedures per-month-per-region was similar to those predicted for centers in the >100km (Figure 1). However, for centers <100km from the border, the average number of procedures was higher than expected during the month immediately following the start of the war in Ukraine (by an estimated 15 (11-19) more procedures within the <100km region), compared with predicted levels based on historic trends (Figure 1). This recovered to expected levels after 30 days of post war period initiation. Similar findings were found in the sensitivity analysis considering regions of </>200km, and in the secondary analysis that included thrombolysis cases.

Procedural Outcomes and Processes of Care

Within the <100km region, the proportion of procedural fatality rate cases approximately doubled pre-war to during-war, although this was not significantly after multivariable adjustment (OR 2.24, 95% CI: 0.78, 6.48; Table 2). In the >100km region, fatality rate was similar pre- and during-war OR 1.01, 95% CI: 0.66, 1.55), and there was no evidence of a difference-in-difference in the odds of procedural fatality rate between regions (p-value for interaction 0.17, Table 2). This finding was also observed under the sensitivity analysis of </>200km regions and in the analyses of the secondary analysis cohort including thrombolysis cases (Supplementary material, *Tables S5-S7*).

Upon examining quality of care indicators, we found no evidence that the odds of PCI complications were different pre- and during-war in either <100km region or >100km region, with no evidence of a difference-in-difference across regions (Table 2). Similar findings were found for prescription of newer anti-platelet medication, radial access and imaging outcomes.

Discussion

Our analysis reveals that following the Russian invasion of Ukraine and the subsequent displacement of 1.5 million refugees into Poland, there has been an increase in revascularization procedures for STEMI, disproportionately impacting centers within 100km of the border. The rise in numbers has been relatively modest, estimating an additional 15 procedures per month within 100 km of the border. After multivariable adjustment, there was no evidence of a difference in clinical outcomes.

The increase in the number of percutaneous coronary intervention (PCI) procedures has been relatively modest as well, with an estimated 15 extra procedures within 100km of the Ukraine border. This increase may be below expectations considering the acute displacement of over 1.5 million refugees to regions close to the border. Several possibilities could account for this. Firstly, the majority of refugees are women and young children, as men under the age of 60 were prohibited from leaving Ukraine as part of the country's mobilization to the armed forces. Secondly, our analysis is based on primary PCI activity using the Polish national PCI registry as a surrogate for STEMI admissions. It is possible that during this period, a greater proportion of patients with STEMI presented outside the 12-hour timeframe in which primary PCI is believed to be effective. While possible, this is unlikely as we did not observe a difference in either time from pain to first contact or time from pain to angiography/balloon. Furthermore, it is reassuring to note that the increase in primary PCI numbers did not create a bottleneck in the system, causing delays in pain-to-balloon times. A third possibility is that refugees who experienced a STEMI may not have sought medical assistance due to unfamiliarity with the medical system in Poland or a lack of access to medical facilities.

The rise in STEMI admissions observed in the current study in the border regions may not merely result from larger populations due to population displacement alone. Prior research has proposed that in the aftermath of civil unrest and natural disasters, there is an associated increase in the incidence of cardiovascular events. For instance, following the Northridge earthquake in the Los Angeles area in January 1994, a postal survey of more than 100 hospitals in the region indicated that admissions for AMI increased from 149 in the week before to 201 in the week after the earthquake [27]. Additionally, the number of sudden deaths from cardiac causes increased from an average of 4.6 per day in the week before to 24 on the day of the earthquake [28]. This surge in incident MI following major events might extend to the longer term, as heart attack centers reported a three-fold increase in the incidence of acute myocardial infarction two years after Hurricane Katrina [29].

Emotional stress during natural disasters and in war zones may elevate the incidence of acute coronary syndromes through various mechanisms, including excessive sympathetic nervous system activation, glycemic control, exacerbation of coronary artery atherosclerosis, transient endothelial dysfunction or necrosis, and increases in platelet aggregability [29, 30]. Other prospective studies have suggested that the association between psychological distress and cardiovascular disease risk could be largely explained by behavioral processes such as smoking and alcohol intake [31]. Alternatively, it may be related to social factors like missed medications, changed diet, poor living conditions, and the stress of disorder and crime following the event [32].

We observed an increase in in-hospital fatality rate in centers within 100km of the borders following the invasion of Ukraine, although this significance diminished when adjusting for differences in baseline covariates. This is reassuring since we did not identify an impact of the war on the process of care, such as pain-to-balloon time or the prescription of newer antiplatelet agents. However, considering the relatively large confidence intervals for the odds of mortality pre-war/post-war (OR 2.22, 95% CI: 0.77-6.42), we cannot entirely rule out an effect on fatality rate. Limited number of overall cases in centers within 100km of the borders could affect the statistical power to detect differences. Stresses to the system may still have resulted in decreases in the quality of care delivered in these regions, which are not captured by the ORPKI dataset. These unobserved factors, known to impact clinical outcomes, include admission to coronary care, prescription of statins, beta-blockers, and ACE inhibitors [33].

Our study did not identify a population shift towards a worse risk factor profile following the influx of refugees, as the average age of patients treated at the border centers did not change following the invasion. Similar risk factor profiles were evident pre- and post-invasion, with comparable proportions of Killip class III/IV presentations. It is likely that the healthcare impact will be much greater than reported in our study, facing challenges around the receipt of longer-term antiplatelet agents in a mobile population that may lack access to continuing medical care. Additionally, challenges may arise in secondary prevention, including optimal blood pressure control, lipid management, cardiac rehabilitation, and altered availability of usual medication due to supply chain issues. Furthermore, as highlighted previously, the impact of natural disasters, wars, and other social upheavals may affect cardiovascular health several years post the index event.

Previous studies examining the impact of conflict events on ACS have reported varied findings. One study indicated that the incidence of admission for AMI increased during the first 5 days of air raids (IRR 2.43; 95% CI 1.23–4.26), and other studies noted a significant rise in the number of patients with wartime ACS in Bosnia and Herzegovina compared to the pre-war period [34-36]. In contrast, a study focusing on coronary care unit admissions at eight centers in New York City after the September 11 terrorist attacks on the World Trade Center did not find a significant change in the number of admissions for ACS or chest pain in the week following the attacks [37]. Our study contributes to this body of literature by evaluating processes of care and clinical outcomes and assessing whether they have been impacted by population shifts, particularly in relation to the geographical proximity to the conflict zone. Despite literature highlighting correlations between humanitarian emergencies and cardiovascular morbidity and mortality, much of the planning of humanitarian responses has concentrated on communicable diseases. The findings of our analysis suggest that the consideration of acute cardiovascular diseases such as AMI in disaster planning and response efforts may help mitigate cardiovascular morbidity and mortality.

Limitations

Our analysis has several limitations. First, it utilizes the ORPKI national PCI registry which will only capture STEMI admissions that proceed to primary PCI, not the total number of STEMI presentations. Second, the ORPKI dataset does not link to longer term outcomes and so cannot provide insight whether the worse clinical outcomes following the Ukraine invasion in border regions translate to worse longer-term outcomes. Thirdly, while we could model the changes in the number of procedures per month, we did not have data on which PCI procedures were performed on Ukrainian refugees specifically. Fourthly, limited number of PCI cases in regions within 100 km of the borders may affect the statistical strength of the study. Finally, our results should not be interpreted as causal, although we have used propensity score analyses to adjust our estimates for observed confounders.

Conclusions

In conclusion, our analysis of the national Polish PCI registry reveals that, following the Russian invasion of Ukraine and the displacement of 1.5 million people, there was only a modest and temporary increase in primary PCI activity, predominantly in centers located within 100km of the border. However, there was no significant impact on in-hospital fatality rate. Our findings suggest that there should be a prioritized focus on planning for both monitoring and management of cardiac diseases in conflict zones and scenes of natural disasters.

Supplementary material Supplementary material is available at www.mp.pl/paim.

Article information

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Data availability statement The data underlying this article will be shared on reasonable request to the corresponding author.

Conflict of interest None declared.

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Table 1 Baseline summary table for the primary percutaneous coronary intervention cohort, excluding thrombolysis cases, for the main analysis

Characteristics	**Overall (N = 90 115[a])**	**Region <100km**			**Region >100km**		
		Pre-war (N = 3,854[a])	**During-war (N = 154[a])**	***P* value[b]**	**Pre-war (N = 82 736[1])**	**During-war (N = 3371[1])**	***P* value[b]**
Age	65 (12)	66 (12)	67 (11)	0.53	65 (12)	66 (12)	0.02
Gender				0.61			0.86
Female	28 636 (32%)	1222 (32%)	52 (34%)		26 287 (32%)	1075 (32%)	
Male	61 237 (68%)	2618 (68%)	102 (66%)		56 233 (68%)	2284 (68%)	
(Missing)	242	14	0		216	12	

Diabetes	15 751 (17%)	606 (16%)	23 (15%)	0.79	14 528 (18%)	594 (18%)	0.93
Previous Stroke	2786 (3.1%)	118 (3.1%)	6 (3.9%)	0.48	2577 (3.1%)	85 (2.5%)	0.05
Previous MI	11 278 (13%)	465 (12%)	20 (13%)	0.73	10 360 (13%)	433 (13%)	0.58
Previous PCI	11 100 (12%)	448 (12%)	22 (14%)	0.31	10 173 (12%)	457 (14%)	0.03
Previous CABG	1522 (1.7%)	48 (1.2%)	1 (0.6%)	1.0	1419 (1.7%)	54 (1.6%)	0.62
Previous Smoker	28 023 (31%)	1023 (27%)	32 (21%)	0.11	25 974 (31%)	994 (29%)	0.02
Hypertension	52 609 (58%)	2613 (68%)	99 (64%)	0.36	47 967 (58%)	1930 (57%)	0.40

Kidney disease	3059 (3.4%)	153 (4.0%)	4 (2.6%)	0.39	2817 (3.4%)	85 (2.5%)	0.01
COPD	1998 (2.2%)	95 (2.5%)	1 (0.6%)	0.18	1834 (2.2%)	68 (2.0%)	0.44
Cardiac arrest at baseline	3816 (4.2%)	181 (4.7%)	8 (5.2%)	0.77	3508 (4.2%)	119 (3.5%)	0.04
Killip class				0.21			0.61
I	62 654 (83%)	2639 (87%)	97 (84%)		57 632 (83%)	2286 (83%)	
II	7865 (10%)	227 (7.4%)	8 (7.0%)		7328 (11%)	302 (11%)	
III	2415 (3.2%)	65 (2.1%)	6 (5.2%)		2265 (3.2%)	79 (2.9%)	
IV	2726 (3.6%)	116 (3.8%)	4 (3.5%)		2510 (3.6%)	96 (3.5%)	
(Missing)	14 455	807	39		13 001	608	

ASA pre cath-lab	66 321 (74%)	2891 (75%)	112 (73%)	0.52	60 766 (73%)	2552 (76%)	0.00
ASA during angiogram or PCI	72 368 (80%)	3190 (83%)	131 (85%)	0.46	66 298 (80%)	2749 (82%)	0.04
UFH pre cath-lab	48 679 (54%)	2590 (67%)	103 (67%)	0.93	44 142 (53%)	1844 (55%)	0.12
UFH during angiogram or PCI	79 024 (88%)	3629 (94%)	152 (99%)	0.02	72 310 (87%)	2933 (87%)	0.50
LMWH pre cath-lab	1755 (1.9%)	41 (1.1%)	3 (1.9%)	0.24	1517 (1.8%)	194 (5.8%)	<0.001
LMWH during angiogram or PCI	3651 (4.1%)	53 (1.4%)	3 (1.9%)	0.48	3391 (4.1%)	204 (6.1%)	<0.001
GPI IIb/ IIIa	24 349 (27%)	888 (23%)	44 (29%)	0.11	22 619 (27%)	798 (24%)	<0.001

Results of angiography				0.61			0.70
LMCA	6539 (7.3%)	251 (6.5%)	13 (8.4%)		6017 (7.3%)	258 (7.7%)	
Multi Vessel Disease	43 394 (48%)	1895 (49%)	76 (49%)		39 812 (48%)	1611 (48%)	
Single Vessel Disease	40 182 (45%)	1708 (44%)	65 (42%)		36 907 (45%)	1502 (45%)	
Bivalirudin	610 (0.7%)	11 (0.3%)	0 (0%)	1.0	579 (0.7%)	20 (0.6%)	0.47
FFR	189 (0.2%)	9 (0.2%)	0 (0%)	1.0	172 (0.2%)	8 (0.2%)	0.71
Intra-vascular imaging	1531 (1.7%)	99 (2.6%)	5 (3.2%)	0.60	1302 (1.6%)	125 (3.7%)	<0.001
Aspiration thrombectomy	9544 (11%)	609 (16%)	25 (16%)	0.89	8586 (10%)	324 (9.6%)	0.15
Rotablation	103 (0.1%)	2 (<0.1%)	0 (0%)	1.0	98 (0.1%)	3 (<0.1%)	1.0

Access site				<0.001			<0.001
Femoral - both	15 170 (17%)	943 (24%)	15 (9.7%)		13 863 (17%)	349 (10%)	
Radial - both	72910 (81%)	2813 (73%)	138 (90%)		67 012 (81%)	2947 (87%)	
Radial Angio - Femoral PCI	1041 (1.2%)	67 (1.7%)	1 (0.6%)		940 (1.1%)	33 (1.0%)	
Femoral Angio - Radial PCI	315 (0.3%)	16 (0.4%)	0 (0%)		292 (0.4%)	7 (0.2%)	
Other	679 (0.8%)	15 (0.4%)	0 (0%)		629 (0.8%)	35 (1.0%)	
Total contrast	166 (70)	193 (77)	180 (67)	0.03	165 (70)	156 (63)	<0.001
(Missing)	2651	110	0		2,431	110	

Total radiation dose	834 (731)	892 (804)	650 (620)	<0.001	836 (730)	730 (645)	<0.001
(Missing)	2464	117	0		2235	112	
RCA	36 833 (41%)	1602 (42%)	62 (40%)	0.75	33 850 (41%)	1319 (39%)	0.04
First/ Second AC Marginal	139 (0.2%)	4 (0.1%)	0 (0%)	1.0	130 (0.2%)	5 (0.1%)	0.90
LMCA	2314 (2.6%)	86 (2.2%)	7 (4.5%)	0.09	2129 (2.6%)	92 (2.7%)	0.58
LAD	37 353 (41%)	1579 (41%)	67 (44%)	0.53	34 291 (41%)	1416 (42%)	0.52
First/ Second Diagonal	4190 (4.6%)	189 (4.9%)	6 (3.9%)	0.57	3857 (4.7%)	138 (4.1%)	0.12
Circumflex	12 164 (13%)	526 (14%)	19 (12%)	0.64	11 137 (13%)	482 (14%)	0.16

First/ Second/ Third Obtuse Marginal	3775 (4.2%)	147 (3.8%)	7 (4.5%)	0.64	3490 (4.2%)	131 (3.9%)	0.35
Ramus Intermedius	924 (1.0%)	36 (0.9%)	4 (2.6%)	0.07	851 (1.0%)	33 (1.0%)	0.78
Direct transport	24 093 (27%)	856 (22%)	63 (41%)	<0.001	22 209 (27%)	965 (29%)	0.02

a Mean (SD); n (%)

b Wilcoxon rank sum test; Pearson's Chi-squared test; Fisher's exact test

Abbreviations: ASA, acetylsalicylic acid; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; FFR, fractional flow reserve; GPI IIb/IIIa, glycoprotein 2b3a; LAD, left anterior descending coronary artery; LMCA, left main coronary artery; LMWH, low molecular weight heparin; MI, myocardial infarction; PCI, percutaneous coronary intervention; RCA, right coronary artery; UFH, unfractionated heparin

Table 2 Association of war in Ukraine starting with clinical outcomes following primary percutaneous coronary intervention cohort, excluding thrombolysis cases, for the <100km vs. >100km analysis

Outcomes	Region <100km			Region >100km			*P*-value for interaction[b]
	Pre-war (N = 3854)	During-war (N = 154)	aOR (95% CI)[a]	Pre-war (N = 82 736)	During-war (N = 3371)	aOR (95% CI)[a]	
Procedural fatality rate	47 (1.22%)	5 (3.25%)	2.24 (0.78, 6.48)	825 (1.00%)	24 (0.71%)	1.01 (0.66, 1.55)	0.17
PCI Complications	188 (4.88%)	14 (9.09%)	1.10 (0.59, 2.05)	3458 (4.18%)	109 (3.23%)	0.79 (0.64, 0.97)	0.31
New Anti-Platelet	1855 (57.5%)	103 (74.1%)	0.73 (0.47, 1.13)	31 537 (46.4%)	1765 (63.9%)	0.62 (0.56, 0.69)	0.47
Radial Access	2829 (73.4%)	138 (89.6%)	1.15 (0.66, 2.01)	67 304 (81.4%)	2954 (87.6%)	0.94 (0.84, 1.06)	0.49
Imaging (IVUS/ OCT)	99 (2.57%)	5 (3.25%)	0.66 (0.25, 1.73)	1302 (1.57%)	125 (3.71%)	0.86 (0.69, 1.06)	0.61

a Odds ratios were adjusted for time since study start, covid-19, propensity score (see Supplementary material, *Table S1*) and hospital-level random effect; see Methods

b *P* value for interaction tests the interaction between the pre-/during-war period indicator variable with region indicator variable, to determine whether the difference in outcomes between prior-/during-war periods differ by region

Abbreviations: aOR, adjusted odds ratios; CI, confidence intervals; IVUS, intravascular litotripsy; OCT, optical coherent tomography; PCI, percutaneous coronary intervention

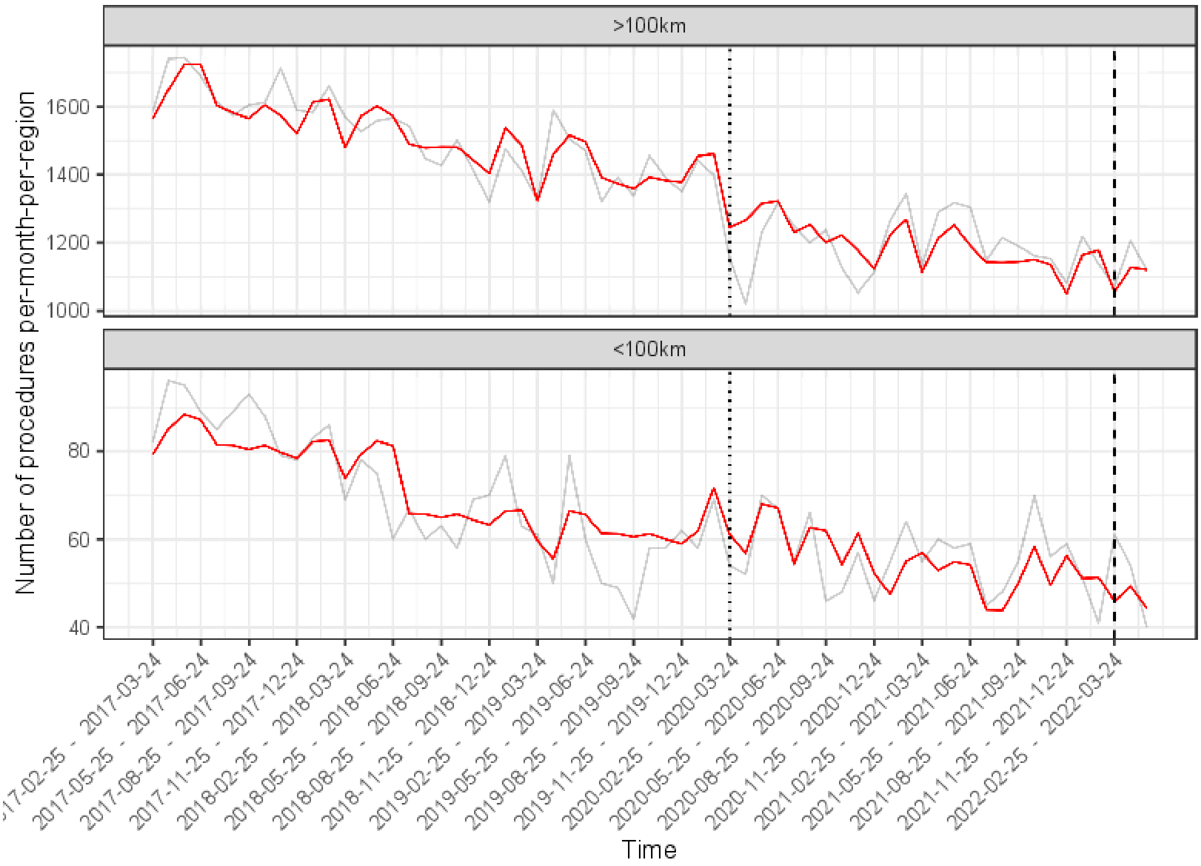

Figure 1 Observed (grey) and predicted (red) number of procedures per month per region. The dotted line depicts the start of COVID-19, with the dashed line representing first day of war in Ukraine

Short title: PCI outcomes in Poland following war in Ukraine