ORIGINAL ARTICLE

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

Mamas A. Mamas[1,2], Glen P. Martin[3], Marek Grygier[4], Rishi K. Wadhera[5], Christian Mallen[6], Nick Curzen[7,8], Harindra C. Wijeysundera[9,10,11], Amitava Banerjee[12], Evangelos Kontopantelis[3], Muhammad Rashid[1], Janusz Sielski[13], Zbigniew Siudak[13]

1 Keele Cardiovascular Research Group, Centre for Prognosis Research, Keele University, Keele, United Kingdom
2 National Institute for Health and Care Research (NIHR), Birmingham Biomedical Research Centre, Birmingham, United Kingdom
3 Division of Informatics, Imaging and Data Sciences, Faculty of Biology, Medicine and Health, University of Manchester, Manchester, United Kingdom
4 Department of Cardiology, Poznan University of Medical Sciences, Poznań, Poland
5 Richard A. and Susan F. Smith Center for Outcomes Research, Beth Israel Deaconess Medical Center, Boston, United States
6 School for Primary Care and School of Medicine, Keele University, Keele, United Kingdom
7 Faculty of Medicine, University of Southampton, Southampton, United Kingdom
8 Coronary Research Group, University Hospital Southampton, NHS Foundation Trust, Southampton, United Kingdom
9 Schulich Heart Program, Sunnybrook Health Sciences Centre, University of Toronto, Toronto, Canada
10 Temerty Faculty of Medicine, University of Toronto, Toronto, Canada
11 Institute of Health Policy, Management and Evaluation, University of Toronto, Toronto, Canada
12 Institute of Health Informatics, University College London, London, United Kingdom
13 Collegium Medicum, Jan Kochanowski University in Kielce, Kielce, Poland

KEY WORDS

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

EDITORIAL

by Zeymer

Correspondence to:
Mamas A. Mamas, MD, PhD, Keele Cardiovascular Research Group, Centre for Prognosis Research, Keele University, Keele ST35BG, United Kingdom, phone: +44 (0)1782 732933, email: mamasmamas1@yahoo.co.uk
Received: January 9, 2024.
Revision accepted: April 19, 2024.
Published online: April 25, 2024.
Pol Arch Intern Med. 2024; 134 (6): 16737
doi:10.20452/pamw.16737

ABSTRACT

INTRODUCTION The Russian invasion of Ukraine in February 2022 resulted in displacement of approximately 12.5 million refugees to adjacent countries, including Poland, which may have strained health care service delivery.

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

PATIENTS AND METHODS We analyzed all adult patients undergoing percutaneous coronary interventions (PCIs) for STEMI across Poland between February 25, 2017 and May 24, 2022. The investigated health care centers were allocated to regions below and over 100 km from the Polish–Ukrainian border. Mixed-effect generalized linear regression models with random effects per hospital were used to explore the associations between the war in Ukraine and several parameters, and whether these associations differed across the regions below and over 100 km from the border.

RESULTS A total of 90 115 procedures were included in the analysis. The average number of procedures per month was similar to the predicted volume for centers over 100 km from the border, while it was higher than expected (by an estimated median of 15 [interquartile range, 11–19]) for the region below 100 km from the border. There was no difference in adjusted fatality rate or quality of care outcomes for pre- and during-war time in both regions, with no evidence of a difference-in-difference across the regions.

CONCLUSIONS Following the Russian invasion of Ukraine, there was only a modest and temporary increase in the number of primary PCIs, predominantly in the centers situated within 100 km of the Polish–Ukrainian border, although no significant impact on in-hospital fatality rate was found.

WHAT'S NEW?

This study, using Polish data on patients with ST-segment elevation myocardial infarction, sheds light on indirect impacts of the war in Ukraine on a crucial aspect of health care, that is, delivery of primary percutaneous coronary intervention (PCI). It shows that health care centers located within 100 km of the Polish–Ukrainian 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 the PCI rates, the study found no discernible impact on adjusted fatality rate or quality of care outcomes based on the distance from the Polish–Ukrainian border. The analysis outlines the importance of resilient health care system to meet potential health care challenges in conflict zones and scenes of natural disasters.

INTRODUCTION During periods of social and political instability caused by natural disasters, public health crises, and wars, health care delivery is frequently disrupted, affecting the quality of care and leading to poorer clinical outcomes. For instance, during the COVID-19 pandemic numerous countries implemented social containment measures, commonly referred to as lockdowns, to mitigate the 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-segment elevation myocardial infarction (STEMI).[1-4] A failure to promptly perform revascularization in patients presenting with STEMI is believed to have contributed to increased death rate from acute coronary syndrome (ACS), heart failure, and out-of-hospital cardiac arrest observed in numerous health care systems during the pandemic.[5-7] In addition, COVID-19 itself could influence the pathophysiology of ACS by increasing the risk for its thromboembolic complications.[8] Similarly, natural disasters, such as the Katrina hurricane in the United States, have profoundly affected local health care, impacting not only acute illnesses[9] but also influencing future cardiovascular diseases,[10] and 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 the World War II, with an estimated 8 million people displaced within Ukraine by late May, and 12.5 million Ukrainians crossing the border of Ukraine as of November 15, 2022.[13] A 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 then 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 health care 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 intervention (PCI) (ORPKI), which is maintained by the Jagiellonian University (Kraków, Poland) in collaboration with the Association of Cardiovascular Interventions of the Polish Cardiac Society.[18-22] This study encompassed all adult patients (aged >18 years) who underwent PCI for STEMI in health care 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 our primary focus was on patients primarily treated with PCI. In the 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 were required.

Outcomes The primary outcomes encompassed: 1) the number of patients presenting with STEMI treated with PCI, and how this changed over time; 2) procedural fatality rate; and 3) the occurrence of procedural complications during angiography or PCI. Procedural complications were defined as a composite of events during PCI, including fatality rate, myocardial infarction (MI), no reflow, bleeding at the puncture site, cardiac arrest, allergic reaction, coronary artery perforation during PCI, or stroke or dissection during angiography.

The secondary outcomes, assessing whether quality metrics of STEMI care were compromised, involved consideration of the following: 1) prescription of a newer antiplatelet either pre-catheter laboratory admission or during angiography / PCI (ie, prasugrel or ticagrelor during pre-catheter laboratory admission or angiography / PCI, as opposed to a standard use of clopidogrel), 2) proportion of PCIs performed via radial access, and 3) the use of intravascular imaging (intravascular ultrasound or optical coherence tomography). Patients not prescribed a newer antiplatelet were excluded from the analysis, as the focus was on comparing the odds of prasugrel or ticagrelor prescription vs clopidogrel.

Time periods and regional centers We categorized time periods as before February 24, 2022 (pre-war period) and after February 24, 2022 (during-war period), and classified the medical centers based on their geographic distance from the Polish–Ukrainian border. The distance from the border was determined as the shortest road route from the closest Polish–Ukrainian border crossing. For the primary analysis, we defined the regions as below 100 km vs over 100 km from the border. In a sensitivity analysis, we considered regions of below and over 200 km from the border. The centers within 100 km of the border were deemed most likely to be affected by the refugee influx, but the impact could have potentially extended further, hence the motivation for the sensitivity analysis.

Statistical analysis We summarized baseline characteristics for the whole cohort and for individual regions across the pre- and during-war periods. Continuous variables were summarized using the mean and SD and compared using the *t* tests or analysis of variance. Categorical variables were summarized using frequencies and were compared using the χ^2 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 the Rubin rules.[23]

We calculated the number of procedures per month and per region across the study period. Given that the war in Ukraine started on February 24, 2022, we calculated each monthly procedure counts from 25th day of the previous month to the 24th day of the current month. To these data, we fitted negative binomial models between February 25, 2017 and December 24, 2021, with covariates of an indicator variable for the region (<100 km vs >100 km for the main analysis, and <200 km vs >200 km for the 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 dates from February 24, 2020 onward, and 0 otherwise), and adjustment for the number of hospitals per region. Using these models, we then predicted the expected number of procedures per month per region, from December 25, 2021 until May 24, 2022. The predicted PCI volume was then compared with the observed monthly volume.

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

The measure of statistical significance was set to a *P* value below 0.05. All analyses were undertaken in R software version 4.2.0,[24] along with the "tidyverse",[25] "mice," and "lme4" packages[26] (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS Out of a total of 90 793 STEMI procedures included in the ORPKI registry within the study period, 9 were performed in patients younger than 18 years and further 214 were duplicate cases, all of which were excluded. For the primary analysis, another 455 procedures were excluded, as the patients received thrombolysis during angiography or PCI, resulting in 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 less than 100 km from the border.

TABLE 1 provides the baseline characteristics of the primary analysis cohort, both overall and by region-time period combinations, with Supplementary material, *Table S2* summarizing the same data for the secondary analysis cohort that included thrombolysis cases. In the primary analysis cohort, the mean (SD) age was 65 (12) years, and 68% of the patients were men. Overall, 17% had diabetes, 31% were current or previous smokers, and 12% had a history of PCI. As many as 4.4% of the cohort patients presented with cardiac arrest at baseline. A majority (81%) of the whole cohort underwent angiography and PCI via the radial access.

In general, we found that the baseline characteristics within each region were similar across the time periods before and during the war (TABLE 1; Supplementary material, *Tables S2–S4*). However, in the centers located over 100 km from the border, the proportion of patients with previous PCI, previous smokers, and those with kidney disease were significantly different before and after February 24, 2022; such differences were not significant in the centers located less than 100 km from the border (TABLE 1). Interestingly, the proportion of patients who were directly transported increased substantially during the war for the centers within 100 km of the border (from 22% before February 24, 2022 to 41% after this date).

TABLE 1 Baseline characteristics of the primary percutaneous coronary intervention cohort, excluding thrombolysis cases, the main analysis (continued on the next page)

Parameter		Overall (n = 90 115)	Region <100 km			Region >100 km		
			Pre-war (n = 3854)	During war (n = 154)	*P* value	Pre-war (n = 82 736)	During war (n = 3371)	*P* value
Age, mean (SD)		65 (12)	66 (12)	67 (11)	0.53	65 (12)	66 (12)	0.02
Sex	Women	28 636 (32)	1222 (32)	52 (34)	0.61	26 287 (32)	1075 (32)	0.86
	Men	61 237 (68)	2618 (68)	102 (66)		56 233 (68)	2284 (68)	
	Missing data	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)	>0.99	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)	0.4
Kidney disease		3059 (3.4)	153 (4)	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)	0.44
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	I	62 654 (83)	2639 (87)	97 (84)	0.21	57 632 (83)	2286 (83)	0.61
	II	7865 (10)	227 (7.4)	8 (7)		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 data	14 455	807	39		13 001	608	
ASA, pre-catheter laboratory admission		66 321 (74)	2891 (75)	112 (73)	0.52	60 766 (73)	2552 (76)	<0.001
ASA, during angiography or PCI		72 368 (80)	3190 (83)	131 (85)	0.46	66 298 (80)	2749 (82)	0.04
UFH, pre-catheter laboratory admission		48 679 (54)	2590 (67)	103 (67)	0.93	44 142 (53)	1844 (55)	0.12
UFH, during angiography or PCI		79 024 (88)	3629 (94)	152 (99)	0.02	72 310 (87)	2933 (87)	0.50
LMWH, pre-catheter laboratory admission		1755 (1.9)	41 (1.1)	3 (1.9)	0.24	1517 (1.8)	194 (5.8)	<0.001
LMWH, during angiography 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	LMCA disease	6539 (7.3)	251 (6.5)	13 (8.4)	0.61	6017 (7.3)	258 (7.7)	0.7
	Multivessel 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	>0.99	579 (0.7)	20 (0.6)	0.47
FFR		189 (0.2)	9 (0.2)	0	>0.99	172 (0.2)	8 (0.2)	0.71
Intravascular imaging		1531 (1.7)	99 (2.6)	5 (3.2)	0.6	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	>0.99	98 (0.1)	3 (<0.1)	>0.99
Access site	Femoral – any side	15 170 (17)	943 (24)	15 (9.7)	<0.001	13 863 (17)	349 (10)	<0.001
	Radial – any side	72 910 (81)	2813 (73)	138 (90)		67 012 (81)	2947 (87)	
	Radial angiofemoral PCI	1041 (1.2)	67 (1.7)	1 (0.6)		940 (1.1)	33 (1)	
	Femoral angioradial PCI	315 (0.3)	16 (0.4)	0		292 (0.4)	7 (0.2)	
	Other	679 (0.8)	15 (0.4)	0		629 (0.8)	35 (1)	
Total contrast		166 (70)	193 (77)	180 (67)	0.03	165 (70)	156 (63)	<0.001
Missing data		2651	110	0		2431	110	
Total radiation dose, mGy		834 (731)	892 (804)	650 (620)	<0.001	836 (730)	730 (645)	<0.001
Missing data		2464	117	0		2235	112	

TABLE 1 Baseline characteristics of the primary percutaneous coronary intervention cohort, excluding thrombolysis cases, the main analysis (continued from the previous page)

Parameter		Overall (n = 90 115)	Region <100 km			Region >100 km		
			Pre-war (n = 3854)	During war (n = 154)	*P* value	Pre-war (n = 82 736)	During war (n = 3371)	*P* value
Infarct-related artery	RCA	36 833 (41)	1602 (42)	62 (40)	0.75	33 850 (41)	1319 (39)	0.04
	LMCA	2314 (2.6)	86 (2.2)	7 (4.5)	0.09	2129 (2.6)	92 (2.7)	0.58
	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)	36 (0.9)	4 (2.6)	0.07	851 (1)	33 (1)	0.78
Direct transport		24 093 (27)	856 (22)	63 (41)	<0.001	22 209 (27)	965 (29)	0.02

Data are presented as number and percentage unless indicated otherwise.

Abbreviations: ASA, acetylsalicylic acid; CABG, coronary artery bypass grafting; COPD, chronic obstructive pulmonary disease; FFR, fractional flow reserve; GPI, glycoprotein; 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

Percutaneous coronary intervention 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 with time, which became evident rapidly post–COVID-19. Overall, there was little change upon the war starting in Ukraine, but this varied across regions. Specifically, when comparing the predicted and observed monthly volume per region (based on historic trends), the actual average number of procedures per month per region was similar to that predicted for the centers located over 100 km from the border (FIGURE 1). However, in the centers situated less than 100 km from the border, the average number of procedures was higher than expected during the month immediately following the beginning of the war in Ukraine (by an estimated median of 15 [interquartile range, 11–19] more procedures), as compared with predicted levels based on historic trends (FIGURE 1). The value returned to the expected levels after 30 days. Similar results were obtained in the sensitivity analysis covering the regions below and over 200 km from the border, and in the secondary analysis that included thrombolysis cases.

Procedural outcomes and parameters of care In the region closer to the border (<100 km), the procedural fatality rate approximately doubled after the war began, but this increase was found insignificant after multivariable adjustment (OR, 2.24; 95% CI, 0.78–6.48; TABLE 2). In the region located further from the border (>100 km), the fatality rate was similar before and during the war (OR, 1.01; 95% CI, 0.66–1.55), and there was no evidence of a difference-in-difference for the odds of procedural fatality rate between the regions (*P* value for the interaction was 0.17; TABLE 2). This was also observed in the sensitivity analysis for the regions located less and more than 200 km from the border, and in the secondary analysis cohort including thrombolysis cases (Supplementary material, *Tables S5–S7*).

Upon examining quality of care indicators, we found no differences for the odds of PCI complications before and during the war in the regions closer to and further from the border, and also no evidence of a difference-in-difference across the regions (TABLE 2). Our findings were similar for the prescription of newer antiplatelet medication, radial access, and imaging outcomes.

DISCUSSION Our analysis revealed 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 the centers within 100 km of the border. The rise in numbers has been relatively modest, estimating 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 PCIs has been relatively modest as well, with estimated 15 extra procedures within 100 km of the Polish–Ukrainian border. This rise may be below expectations considering the sudden displacement of over 1.5 million refugees to the regions close to the border. There are several possible explanations. First, a majority of the refugees were women with young children, as men under the age of 60 were prohibited from leaving Ukraine as part of the country's enlistment regulations. Second, our analysis was based on the 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

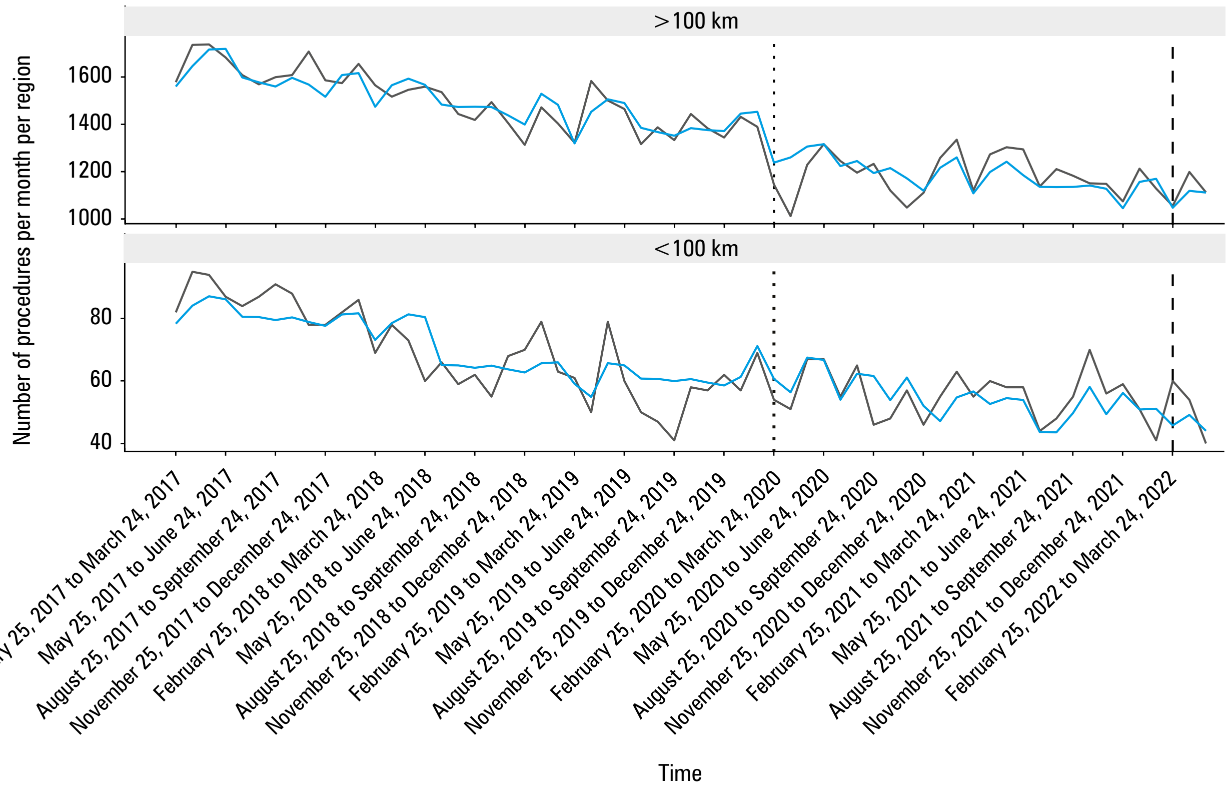

FIGURE 1 Observed (grey) and predicted (blue) number of procedures per month per region. The dotted line represents the beginning of the COVID-19 pandemic, and the dashed line represents the first day of the war in Ukraine.

outside the 12-hour timeframe in which primary PCI is believed to be effective. Although 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 angioplasty. Furthermore, it is reassuring to note that the increase in primary PCI number did not create a bottleneck in the system, causing delays in pain-to-balloon times. A third possibility is that the refugees who experienced 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 (<100 km) may not have resulted merely from the population enlargement due to the refugee displacement. Prior research showed that civil unrests and natural disasters are associated with higher 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 acute MI (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 last for extended time periods, as heart attack centers reported a 3-fold increase in the incidence of AMI 2 years after the Katrina hurricane in the United States.[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 increase 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 behaviors such as smoking and alcohol intake.[31] Alternatively, it may be related to social factors, such as missed medications, changed diet, poor living conditions, and stress due to commotion and crime following the event.[32]

We observed an increase in in-hospital fatality rate in the centers within 100 km of the border following the Russian invasion of Ukraine, although its significance diminished when adjusting for differences in baseline covariates. This is reassuring, since we did not identify an impact of the war on the patient care parameters, such as pain-to-balloon time or prescription of newer antiplatelet agents. However, considering the relatively large confidence intervals for the odds of mortality before and during the war (OR, 2.22; 95% CI, 0.77–6.42), we cannot entirely rule out the effect on fatality rate. Limited total number of cases in the centers within 100 km of the border could have affected the statistical power to detect differences. The challenge to the health care system may still have resulted in lowering the quality

TABLE 2 Associations between the beginning of the Russian invasion of Ukraine and clinical outcomes in the primary percutaneous coronary intervention cohort, excluding thrombolysis cases, for the regions within and over 100 km from the Polish–Ukrainian border

Outcomes	Region <100 km			Region >100 km			*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)	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 antiplatelet medication	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

Data are presented as number and percentage.

a Odds ratios were adjusted for time since the beginning of the study, COVID-19, propensity score (see Supplementary material, *Table S1*), and hospital-level random effect; see Supplementary material, *Methodology*.

b *P* value for interaction tested the interaction between the pre- and during-war period indicator variable with region indicator variable, to determine whether the outcomes between the pre- and during-war periods differed by region.

Abbreviations: aOR, adjusted odds ratio; IVUS, intravascular ultrasound; OCT, optical coherence tomography; others, see TABLE 1

of care delivered in these regions, which was not captured by the ORPKI dataset. These unobserved factors, known to impact clinical outcomes, include admission to coronary care, prescription of statins, β-blockers, and angiotensin-converting enzyme inhibitors.[33]

Our study did not identify a population shift toward a worse risk factor profile following the influx of refugees, as the average age of the patients treated at the border centers did not change following the invasion. The risk factor profiles were similar before and during the invasion, with comparable proportions of Killip class III/IV presentations. It is likely that the impact on the health care was much greater than reported in our study, with challenges involving prescription of longer-term antiplatelet agents to a population of migrants who may lack a stable access to 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 reported variable findings. One study indicated that the incidence of admissions for AMI increased during the first 5 days of air raids (incident rate ratio, 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 as compared with the pre-war period.[34-36] In contrast, a study focusing on coronary care unit admissions at 8 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 the parameters of patient care and clinical outcomes, and assessing whether they have been impacted by population shifts, particularly in relation to the geographic proximity to the conflict zone. Despite papers highlighting correlations between humanitarian crises 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 only captures the 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 therefore cannot explain if the worse clinical outcomes following the Russian invasion of Ukraine translate into worse longer-term outcomes in the border regions. Third, while we could model the changes in the number of procedures per month, we did not have data on which PCI procedures were performed in the Ukrainian refugees specifically. Fourth, limited number of PCI cases in the regions within 100 km of the borders may affect the statistical power of the study. Finally, our results should not be interpreted as causal, although we have used propensity score analyses to adjust our estimates for the 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 into Poland, there was only a modest and temporary increase in primary PCI activity, predominantly in the centers located within 100 km of the Polish–Ukrainian border. However, there was no significant impact on in-hospital fatality rate. Our findings suggest that planning for both monitoring and management of cardiac diseases should be prioritized in conflict zones and scenes of natural disasters.

SUPPLEMENTARY MATERIAL

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

ARTICLE INFORMATION

ACKNOWLEDGMENTS None.

FUNDING None.

CONTRIBUTION STATEMENT MAM: conceptualization, methodology, formal analysis, investigation, resources, validation, writing of the original draft, writing (reviewing and editing), supervision, project administration; GPM: data analysis, writing of the original draft, writing (reviewing and editing); MG, RKW, NC, HKW, AB, EK, MR: conceptualization, methodology, writing of the original draft, writing (reviewing and editing), validation; JS: data curation, conceptualization, methodology, writing of the original draft, writing (reviewing and editing), validation; ZS: conceptualization, methodology, formal analysis, investigation, resources, validation, writing of the original draft, writing (reviewing and editing), supervision, project administration, funding acquisition. All authors edited and approved the final version of the manuscript.

CONFLICT OF INTEREST None declared.

HOW TO CITE Mamas MA, Martin GP, Grygier M, et al. Indirect impact of the war in Ukraine on primary percutaneous coronary intervention for ST-segment elevation myocardial infarction in Poland. Pol Arch Intern Med. 2024; 134: 16737. doi:10.20452/pamw.16737

REFERENCES

1 Garcia S, Albaghdadi MS, Meraj PM, et al. Reduction in ST-segment elevation cardiac catheterization laboratory activations in the United States during COVID-19 pandemic. J Am Coll Cardiol. 2020; 75: 2871-2872.

2 Kwok CS, Gale CP, Kinnaird T, et al. Impact of COVID-19 on percutaneous coronary intervention for ST-elevation myocardial infarction. Heart. 2020; 106: 1805-1811.

3 Mafham MM, Spata E, Goldacre R, et al. COVID-19 pandemic and admission rates for and management of acute coronary syndromes in England. Lancet. 2020; 396: 381-389.

4 Nadarajah R, Wu J, Hurdus B, et al. The collateral damage of COVID-19 to cardiovascular services: a meta-analysis. Eur Heart J. 2022; 43: 3164-3178.

5 Rashid M, Gale CP, Curzen N, et al. Impact of coronavirus disease 2019 pandemic on the incidence and management of out-of-hospital cardiac arrest in patients presenting with acute myocardial infarction in England. J Am Heart Assoc. 2020; 9: e018379.

6 Wadhera RK, Figueroa JF, Rodriguez F, et al. racial and ethnic disparities in heart and cerebrovascular disease deaths during the COVID-19 pandemic in the United States. Circulation. 2021; 143: 2346-2354.

7 Wu J, Mamas MA, Mohamed MO, et al. Place and causes of acute cardiovascular mortality during the COVID-19 pandemic. Heart. 2021; 107: 113-119.

8 Bil J, Kern A, Bujak K, et al. Clinical characteristics and 12-month outcomes of patients with myocardial infarction with nonobstructive coronary arteries before and during the COVID-19 pandemic. Pol Arch Intern Med. 2023; 133: 16405.

9 Berggren RE, Curiel TJ. After the storm-health care infrastructure in post-Katrina New Orleans. N Engl J Med. 2006; 354: 1549-1552.

10 Peters MN, Moscona JC, Katz MJ, et al. Natural disasters and myocardial infarction: the six years after Hurricane Katrina. Mayo Clin Proc. 2014; 89: 472-477.

11 Cefalu WT, Smith SR, Blonde L, et al. The Hurricane Katrina aftermath and its impact on diabetes care: observations from "ground zero": lessons in disaster preparedness of people with diabetes. Diabetes Care. 2006; 29: 158-160.

12 Inui A, Kitaoka H, Majima M, et al. Effect of the Kobe earthquake on stress and glycemic control in patients with diabetes mellitus. Arch Intern Med. 1998; 158: 274-278.

13 United Nations Refugee Agency. Operational Data Portal (ODP). 2023. https://data.unhcr.org/en/situations/ukraine. Accessed December 15, 2023.

14 Union of Polish Metropolies. Urban hospitality: unprecedented growth, challenges and opportunities. 2022. https://metropolie.pl/fileadmin/user_upload/UMP_raport_Ukraina_ANG_20220429_final.pdf. Accessed December 11, 2023.

15 Chaaya M, Ghandour LA, Fouad FM, et al. Non-communicable diseases among Palestinian refugees from Syria: a cross-sectional study on prevalence, case management, access to and utilisation of UNRWA Health Services. Lancet. 2021; 398: S22.

16 Collins DRJ, Jobanputra K, Frost T, et al. Cardiovascular disease risk and prevention amongst Syrian refugees: mixed methods study of Médecins Sans Frontières programme in Jordan. Confl Health. 2017; 11: 14.

17 Hayman KG, Sharma D, Wardlow RD, et al. Burden of cardiovascular morbidity and mortality following humanitarian emergencies: a systematic literature review. Prehosp Disaster Med. 2015; 30: 80-88.

18 Januszek R, Siudak Z, Malinowski KP, et al. Annual operator volume among patients treated using percutaneous coronary interventions with rotational atherectomy and procedural outcomes: analysis based on a large national registry. Catheter Cardiovasc Interv. 2022; 99: 1723-1732.

19 Januszek R, Siudak Z, Malinowski KP, et al. Aspiration thrombectomy in patients with acute myocardial infarction—5-year analysis based on a large national registry (ORPKI). J Clin Med. 2020; 9: 3610.

20 Januszek R, Siudak Z, Dziewierz A, et al. Predictors of in-hospital effectiveness and complications of rotational atherectomy (from the ORPKI Polish National Registry 2014-2016). Catheter Cardiovasc Interv. 2018; 92: E278-E287.

21 Siudak Z, Dudek D, Grygier M, et al. Interventional cardiology in Poland in 2020 - impact of the COVID-19 pandemic. Annual summary report of the Association of Cardiovascular Interventions of the Polish Cardiac Society and Jagiellonian University Medical College. Postepy Kardiol Interwencyjnej. 2021; 17: 131-134.

22 Siudak Z, Tokarek T, Dziewierz A, et al. Reduced periprocedural mortality and bleeding rates of radial approach in ST-segment elevation myocardial infarction. Propensity score analysis of data from the ORPKI Polish National Registry. EuroIntervention. 2017; 13: 843-850.

23 Sterne JAC, White IR, Carlin JB, et al. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. BMJ. 2009; 338: b2393.

24 R Development Core Team R: a language and environment for statistical computing. R Foundation for Statistical Computing. 2017. www.R-project.org. Accessed May 3, 2023.

25 Wickham H, Averick M, Bryan J, et al. Welcome to the Tidyverse. J Open Source Soft. 2019; 4: 1686.

26 van Buuren S, Groothuis-Oudshoorn K. MICE: multivariate imputation by chained equations in R. J Open Source Soft. 2011; 45: 1-67.

27 Leor J, Poole WK, Kloner RA. Sudden cardiac death triggered by an earthquake. N Engl J Med. 1996; 334: 413-419.

28 Leor J, Kloner RA. The Northridge earthquake as a trigger for acute myocardial infarction. Am J Cardiol. 1996; 77: 1230-1232.

29 Gautam S, Menachem J, Srivastav SK, et al. Effect of Hurricane Katrina on the incidence of acute coronary syndrome at a primary angioplasty center in New Orleans. Disaster Med Public Health Prep. 2009; 3: 144-150.

30 Ford ES, Mokdad AH, Link MW, et al. Chronic disease in health emergencies: in the eye of the hurricane. Prev Chronic Dis. 2006; 3: A46.

31 Hamer M, Molloy GJ, Stamatakis E. Psychological distress as a risk factor for cardiovascular events: pathophysiological and behavioral mechanisms. J Am Coll Cardiol. 2008; 52: 2156-2162.

32 Lavie CJ, Gerber TC, Lanier WL. Hurricane Katrina: the infarcts beyond the storm. Disaster Med Public Health Prep. 2009; 3: 131-135.

33 Siudak Z, Bartuś S, Hawranek M, et al. Interventional cardiology in Poland in 2021. Annual summary report of the Association of Cardiovascular Interventions of the Polish Cardiac Society (AISN PTK) and Jagiellonian University Medical College. Postepy Kardiol Interwencyjnej. 2022; 18: 87-89.

34 Zubaid M, Suresh CG, Thalib L, et al. Could missile attacks trigger acute myocardial infarction? Acta Cardiol. 2006; 61: 427-431.

35 Bergovec M, Heim I, Vasilj I, et al. Acute coronary syndrome and the 1992-1995 war in Bosnia and Herzegovina: a 10-year retrospective study. Mil Med. 2005; 170: 431-434.

36 Vasilj I, Bergovec M, Kvesić A, et al. Acute coronary syndrome frequency in western Herzegovina over the fifteen year period (1987-2001). Coll Antropol. 2006; 30: 915-919.

37 Chi JS, Speakman MT, Poole WK, et al. Hospital admissions for cardiac events in New York City after September 11, 2001. Am J Cardiol. 2003; 92: 61-63.