







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Estimating the impact of the Russian invasion on the displacement of graduating high school students in Ukraine

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On 24 February 2022, Russia began a full-scale invasion of Ukraine. The war has dramatically impacted every area of life in Ukraine, including education. In this paper, we curate a uniquely comprehensive dataset of standardized exam outcomes used for admissions to higher education institutions in Ukraine—analogue to the Standardized Aptitude Test (SAT) in the United States—to provide strong estimates of student displacement and the first analysis of student *drop-off*, or decline of participation in the Ukrainian education system, following the Russian full-scale invasion. We conducted descriptive statistical analysis, which included computing and comparing means across groups of students, conditioned on geographic location, migration pattern, and demographics, coupled with data visualization. We found that, among the graduating Ukrainian high school students in 2022, approximately 36,500 (16%) were displaced, with 64% of them moving abroad, primarily to Poland, Germany, and Czechia. Most displaced students originated from the front-line war regions, and either moved abroad or migrated towards the central and western parts of Ukraine. Further, we found a 21% decline in graduating high school students taking the standardized higher education entrance exam in 2022, as compared to 2021. This *drop-off* from the common educational pathway consists of approximately 41,500 students. With these findings taken together, we estimate that at least 78,000—a staggering 34%—of high school seniors have been directly impacted by the Russian invasion of Ukraine. We also study the impacts on subgroups and at the intersection of socio-economic status (as measured by urban vs. rural location) and gender, and find that intersectionality exacerbates the impacts, with men from rural areas being particularly adversely impacted. We conclude this article by reflecting on several policies pursued by the Ukrainian government and its institutions, aimed at minimizing disruptions to the school year and retaining students. Our analysis has important implications for governmental organizations like the Ukrainian government and the European Union, and human rights organizations like the UN Refugee Agency and the International Organization for Migration who wish to understand the impact of the Russian invasion on the education system in Ukraine.

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Introduction

The full-scale invasion of Ukraine by Russia has had devastating impacts on the Ukrainian population. The Ukrainian education system has been particularly affected in vast and heterogeneous ways, including the displacement of students and educators, reduced access to educational resources, the destruction of educational infrastructure, psychological trauma, and “brain drain”, when talented human capital chooses to leave their home country due to a *perceived* lack of future opportunities (Lavrysh et al. 2022; Cervantes-Duarte and Fernández-Cano, 2016; Piven, 2022; Tessema, 2010).

According to the Ministry of Education and Science of Ukraine (2022), close to 3800 educational structures have been damaged, with 365 of them being completely destroyed. Almost half of these structures are general secondary education institutions—schools—with over 11% of all schools in Ukraine having been damaged or destroyed (Cedos, 2023). In response, over 84% of educational institutions switched to mixed-mode or fully remote classrooms in the 2022–2023 school year (State Service of Education Quality of Ukraine, 2023). In areas of the country that are close to the front-line of the war, most schools have switched entirely to remote learning (Cedos, 2023).

However, distance education is itself a limited solution to Ukraine’s ongoing education challenges — frequent air alarms, power outages, and interruptions in internet access present barriers to delivering consistent, high-quality education (Cedos, 2023; Ilichuk, 2023; Vox Populi Agency, 2024; Londar and Pietsch, 2023; Melnyk, 2022). A 2022 survey of nearly 55,000 Ukrainian educators uncovered additional challenges, the most pressing of which were the lack of familiarity with information communication technology (ICT) and access to ICT equipment (Ovcharuk et al. 2023). Additionally, widespread psychological trauma is a major impact of war on students and teachers (Thabet and Sultan, 2016; Yousef et al. 2021; Zikic et al. 2015; Sharifian et al. 2023). These and other factors have had a substantial impact on student performance, with students falling at least one full grade, and in some cases as much as two grades, behind their peers in other countries (Angrist et al. 2022; OECD, 2023a, b).

The war, displacement, and “brain drain”. Displacement is a critical issue for countries in conflict as they begin to look towards the future. For example, following the Balkan conflicts in the 1990s, a significant post-war impact on the education systems in Serbia, Croatia, and Bosnia and Herzegovina was the displacement of (and inability to retain) talented teachers and students (Kreso, 2008; Magill, 2010). Similar phenomena of post-conflict “brain drain” have occurred in many other countries affected by military conflict; for example, the Iraq War (2003–2011) led to a large number of Iraqi teachers leaving the country, and a 40% decrease in the number of students attending classes (UNESCO, 2007). The civil war in South Sudan (2013–2020) resulted in an 18% annual decline in school enrollment in conflict-affected regions (Mayai, 2021; UNISEF, 2015).

In Ukraine, the destruction of the educational structures, challenges in distance learning, and concerns over student and teacher safety all contribute to internal and external displacement. After Russia began its first attacks in the Donbas region of Ukraine in 2014, over 1 million people were internally displaced, with many also being displaced abroad (Sasse, 2020; Oleksiyenko et al. 2021; Hladkikh, 2021; Lee et al. 2023; Sajjad, 2022; Kiryukhin, 2019). The full-scale invasion in 2022 has greatly exacerbated displacement and migration. According to the United Nations High Commissioner for Refugees (2023), as of June 2023, there are 6.3 million Ukrainian refugees globally, representing a staggering 15% decrease of the country’s pre-invasion population (43.8 million in 2021).

According to Eurostat (2023), as of October 2023, 4.2 million citizens who fled the country due to the full-scale Russian invasion were granted temporary protection in the EU. Almost a third of the refugees (1.4 million) are children.

In January 2023, information was made available regarding the scale and impact of displacement on Ukraine’s education system. According to the Ministry of Education and Science of Ukraine (2023), 510,405 students and 12,439 school teachers continue to stay abroad. However, to the best of our knowledge, no information is available *about the impact of the war on the internal and external displacement of high school students, or about their drop-off from the typical pathway to higher education.*

Research contributions. We make use of public data on the standardized higher-education entrance exam for Ukrainian high school students — similar to the Scholastic Aptitude Test (SAT) in the United States. The dataset contains exam registrations of approximately 1.5 million graduating high school students, spanning 8 years. We curated and analyzed this data to understand the full scope of the impact of the Russian invasion on two key aspects of Ukraine’s education system: student displacement and decline in participation in the higher-education entrance exam (“drop-off”). Our multi-disciplinary international team comprises researchers and educators based in the United States and in Ukraine, with technical expertise and, crucially, lived experience that allowed us to ground the work of data curation and analysis in the current social and educational context in Ukraine.

First, we offer a detailed estimate of the displacement and migration of graduating high school students. The dataset we use is uniquely suited for this analysis in that it contains information on both where a student is from (i.e., their home location) and where they physically completed the exam (i.e., the location to which they have been displaced).

Next, we offer the first—to the best of our knowledge—estimate of the decline in participation in the standardized exam. Generally, students in conflict zones and among refugee populations are much more vulnerable to leaving the education system (Cahan, 2023). This is a critical group and until this work, little was known about the size or the scope of students impacted by the Russian invasion of Ukraine.

Summary of findings. We estimate that, in 2022, at least 36,500 (16%) of graduating high school students have been displaced. Approximately 64% of the displaced students migrated abroad. Those students who were internally displaced generally originated from Ukraine’s southern and eastern regions (i.e., the front-line regions) and migrated towards the central and western parts of the country. The majority of the students who were displaced abroad migrated to Poland, Germany, and Czechia.

Further, we estimate that, in 2022, the number of graduating high school students who took the exam declined by 41,500 (21%) as compared to 2021, thereby “dropping off” the typical educational pathway. These students are not among the 36,500 whom we report as being displaced, meaning that, in total, *at least 78,000 students—a staggering 34% of all graduating high school seniors—were directly impacted by the war in 2022.*

In a subgroup analysis, we found that the war has adversely impacted students from rural areas. Rural areas in Ukraine are particularly vulnerable because students there generally have less access to educational resources than in urban areas (Skrzyzewska and Karácsonyi, 2012). The most affected intersectional subgroup was rural-male students, among which the percentage decrease of test-takers was more significant than the rural and male groups alone.

Policy reflections. In the final section of this paper, we reflect on policy initiatives taken by the Ukrainian government and its institutions—with support from international and global partners—to maintain the integrity of the country’s education system. These include policies aimed at minimizing disruptions to the academic calendar, such as remote education, as well as the digitization of the standardized exam to ensure its delivery during war time. In that section, we also discuss several efforts to expand educational and research opportunities for students in Ukraine, including new academic partnerships between Ukrainian universities and universities from around the world.

Materials and methods

Data source. The primary data source for this research is standardized exam outcomes used for higher education admissions, provided by the Ukrainian Center for Educational Quality Assessment (UCEQA), which is under the management of the Ministry of Education and Science.¹ The data spans 2016–2023 and includes 2.5 million test takers in total. We focus our analysis on those who registered for the exam in the year in which they graduated from high school (i.e., high school seniors), which is about 1.5 million test takers. The number of high school seniors registering for the exam varies from year to year: about 166,000 of them registered in 2022, and about 181,000 in 2023. See SI Appendix, Table S2 for information regarding the number of registrations by year.

The data includes test takers’ demographics (e.g., location, age, and sex), the school they attend (if any), and their test outcomes for up to 11 subjects, including mathematics, Ukrainian Language Arts, biology, etc. The Ukrainian Language Arts exam was mandatory in 2022 and 2023, and was taken by nearly every student from 2016–2021.

Full details about the dataset and our extensive data curation process can be found in SI Appendix, Section 1.

Additional data source. To help contextualize our analysis, we included a dataset that contains the number of high school graduates per year. This dataset was provided by the State Statistics Service of Ukraine which, in turn, obtains this information from the Ministry of Education and Science.²

Standardized exam details. The exam is used for admissions to higher education institutions in Ukraine, and is strictly required for anyone who wants to attend such an institution. Overwhelmingly, the most common educational roadmap for students in Ukraine is to take this exam in their final year of high school. Note that, from 2016–2019, taking the exam was required for high school graduation. This requirement was lifted in 2020 and 2021 because of the COVID-19 pandemic, and it has not been reinstated during the war.

Note also that other individuals planning to apply for higher education admissions can also take the test, however, in this paper we limit our analysis to high school seniors.

Before the full-scale invasion by Russia in 2022, the examination, then called the External Independent Evaluation (EIE), was paper-based and held over a period of weeks at special testing centers located in schools, universities, and other educational institutions throughout Ukraine. After the start of the invasion, the EIE was replaced with the computer-based National Multi-subject Test (NMT). The NMT was delivered in 2022 and 2023, and it was held in specially designated temporary examination centers throughout Ukraine and 32 countries across the world. We will refer to the EIE and the NMT jointly as “the exam” in the remainder of the paper, and will differentiate between them only when the distinction is important. For a summary of the

differences between the EIE and the NMT, see SI Appendix, Table S1.

Data cleaning and transformation. The open data released annually by the Ukrainian Center for Educational Quality Assessment (UCEQA) represents a commendable effort to make standardized test scores publicly accessible for research. The ease of filtering and downloading data from the open data portal has enabled projects like ours to utilize these valuable resources. However, the practical use of this data presents several challenges that complicate its analysis and integration.

The first challenge is the absence of detailed dataset documentation, which provides little more than single-line descriptions of attributes. Without domain expertise, such as that provided by the Ukrainian members of our research team, interpreting and cleaning the data would have been nearly impossible. This lack of documentation limits the dataset’s accessibility for researchers unfamiliar with the context and, even more critically, can lead to misleading conclusions or the inappropriate use of data for machine learning tasks.

Another persistent challenge is the lack of standardized data entry practices, mainly because the registration process was done on paper through the post office. Inconsistencies not only occur across years but are also present within the same year, making it difficult to reconcile data into a unified format. For example, in location information there were many typos, inconsistent choices of when to use the Latin alphabet vs. the native Cyrillic alphabet, and different name formats (e.g., how the name of an administrative division was abbreviated).

To address these challenges, we undertook an extensive year-long curation process that involved the use of manual and automated cleaning methods. The data was transformed into normalized database tables, harmonized across years, and integrated into a PostgreSQL database for further analysis. Particular attention was devoted to harmonizing and validating information on locations and educational institutions, a critical step described in detail in SI Appendix, Section 1. 2016–2023 was a period with many significant changes in Ukraine, particularly decommunization and decentralization. The former included removing Soviet-era location names and replacing them with names that reflect Ukraine’s national heritage. The latter involved frequent re-districting of territories. To reconcile any inconsistencies, a unique identifier was assigned to each physical location in Ukraine so that it could be tracked consistently throughout the study period. A similar approach was applied to information on educational institutions.

Central variables. In this paper, we explore the impact of the war on the displacement of test takers both within Ukraine and abroad who graduate in the current year. So, central to this study is the use of the **location features** from the dataset. We particularly focus on two such features: the “home” location of the student (i.e., where the student was officially registered), and the “test” location (i.e., where the student registered to take the exam). All Ukrainian locations in this dataset are given at three levels of administrative division: region (oblast), area (raion), and territory (naselenyi punkt). All locations abroad are given at two levels: country and city. For the migration analysis, we use the least-granular level of location: region. We also study the impacts on subgroups, both individually and at the intersection of **socio-economic status** (as measured by urban vs. rural location) and **gender**.

Another central variable for this research was **educational institution type**. This was necessary to select the sample of students graduating from a high school during the year in which

they took the exam. Although this feature is present in the dataset, the set of response categories varies from year to year, and it contains attribution mistakes. For example, in some years, the values of the “participant type” variable in the dataset is limited to “graduate of the current year” and “graduate of previous years,” whereas in others, the categories were changed to “graduate of the current year of a general secondary education institution,” “graduate of the current year of a secondary education institution of another country,” “student of a vocational education institution,” “student of a higher education institution,” and “graduate of previous years.” A detailed description of our full data cleaning process can be found in SI Appendix, Section 1.

Assumptions. We chose the year 2022 for analysis as our primary focus since we assume that the start of the war (February 24, 2022) and the end of the new test registration process (April 19, 2022) was too short to change the official registration record (home location). We also assume that if a person’s home location region does not coincide with the chosen test location, then this represents a displacement event. Later, we will show that these kinds of events were uncommon before the war (with slightly higher numbers during COVID-19).

Limitations. While our curated dataset is uniquely comprehensive in its scope, it has three notable limitations. The exam is taken by students who intend to study at Ukrainian higher education institutions. This means that the dataset does not include information about graduating high school students who intend to study abroad or those who do not intend to enter a higher education institution after graduation. Analyzing data from 2016-2021 shows that approximately 97% of graduates take the exam.

The second limitation is that, because the Ministry of Education and Sciences changed the standardized exam from the EIE to the NMT in 2022, it is difficult to make inferences about student performance across years. The data suggests that the NMT exam was easier than the EIE: Before the war, between 5.4% and 9.7% of students failed Ukrainian Language Arts, while in 2022, fewer than 0.05% failed this subject. Further, the EIE exam itself underwent frequent changes in its content and difficulty between 2016 and 2021, weakening its validity as a measure of student performance over time. This also means that this data is not well-suited for making future predictions or forecasts. Rather, the value in having many years of data comes from contextualizing changes observed during the war years, as compared to the pre-war years (e.g., Table 1).

The third limitation is that we are using secondary data, which lacks detailed contextual information that could enhance the interpretation of results. Consequently, while we can answer questions about the extent of displacement and drop-off, we cannot answer questions about *why* students and families migrated to specific areas based on this data alone.

Analysis approach and methodology. Once data curation was complete, we sought to answer the following key questions related

to the *displacement* of graduating high school students in Ukraine, as well as their *drop-off* from the traditional educational pathway in Ukraine:

(Displacement)

What was the *overall* percentage of displaced graduating high school students?

What percentage of the displaced students was displaced internally vs. externally?

How were different regions of Ukraine impacted by displacement, both in terms of those students displaced *from* and displaced *to* a given region?

How were sub-groups of students (male vs. female, urban vs. rural, and their intersections) impacted by displacement?

(Drop-off) What was the *overall* drop-off in graduating high school students taking the standardized exam?

How were sub-groups of students (male vs. female, urban vs. rural, and their intersections) impacted by drop-off?

Conveniently, these questions could be answered using summary statistics and data visualization from the curated dataset, by conditioning on geographic locations and subgroups. We have included all formulas used to calculate summary statistics in SI Appendix, Section 2. Data visualizations have been included throughout the paper.

Results

Student displacement and migration. We begin by exploring the impact of the war on the displacement of students both within Ukraine and abroad. Our data gives us access to two important variables for this analysis: where the student was *registered for the exam* (i.e., their home location), and where the student *was registered to take the exam* (i.e., the location to which they migrated). As seen in Table 1, in pre-war years, the vast majority of graduating high school students registered for the exam and took the exam in the same region. On average, around 750 students per year had a test location that was different from their home location.

However, in 2022, this number increased dramatically to 36,500 of graduating high school students who registered to take the exam in a different location than the one in which they lived. Put another way, *approximately 36,500 graduating Ukrainian high school students were displaced in 2022*, which corresponds to 16% of all 229,000 high school graduates.

Figure 2a shows the percentage of test takers displaced *from* each region in Ukraine (source of displacement). According to our analysis, the regions most affected by migration were Kherson Oblast, Donetsk Oblast, Luhansk Oblast, Kharkiv Oblast, and Mykolaiv Oblast—all located along the front-line of the war. In each of these regions, 100%, 100%, 100%, 51.5%, and 41% were registered in the respective Oblast, but took the exam elsewhere.

Displacement abroad. Among the roughly 36,500 displaced students, 23,200 (64%) took the exam abroad. Figure 1 shows the proportion of these students per country of destination, with most migrating to Poland (30.7%), Germany (26.9%), and Czechia (8.3%). We find that a large number of students from all across Ukraine—from the front-line war regions to the European border regions—were displaced abroad. We hypothesize that displacement abroad may be most connected to proximity to the front line and the wealth of individuals. Aside from the fully-occupied regions of Luhansk Oblast and Donetsk Oblast, the regions with the most persons displaced abroad were Kharkiv Oblast, Kyiv Oblast, Mykolaivska oblast, Zaporizhzhia Oblast, Dnipropetrovsk Oblast. In 2021 four out of these five regions had the highest GDP per capita among all regions in the country.³

Table 1 The number of students whose test location (i.e., where they registered for the exam) is different than their home location.

Year	2016	2017	2018	2019	2020	2021	2022
Students	1222	509	336	412	1339	777	36,563

We use this as a proxy for student displacement in the war year (bolded).

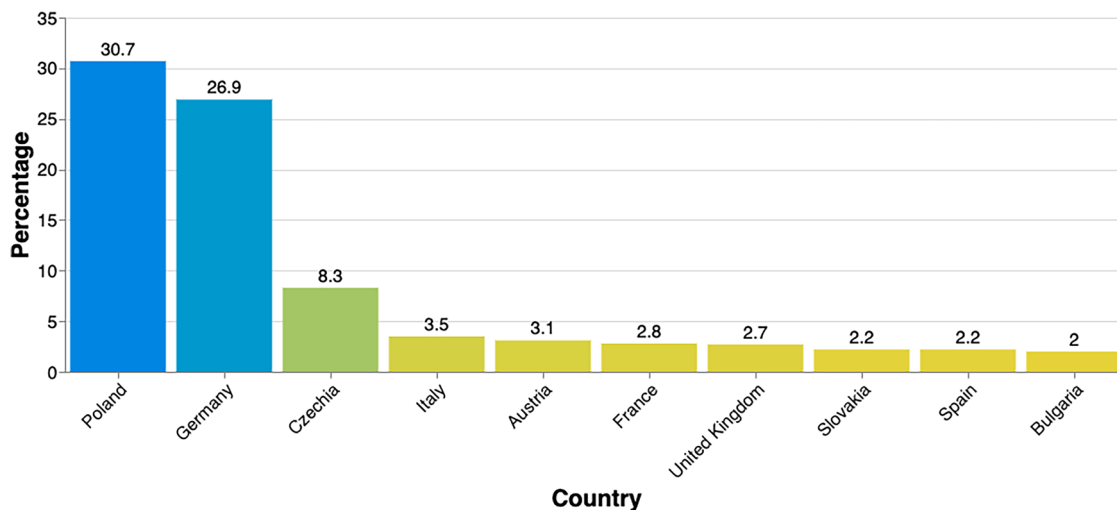


Fig. 1 The top destinations (over 2%) of the approximately 23,200 graduating high school students displaced outside of Ukraine in 2022. The full list of countries can be found in [SI Appendix, Table S3].

Internal displacement. Among the roughly 36,500 displaced students, 36% were displaced internally. Figure 2b shows the proportion of these test takers in each Ukrainian region (destination of displacement). We observe that students primarily migrated towards central and western parts of the country, with 22.2% of internally displaced students migrating to Dnipropetrovsk Oblast, 17.4% to Kyiv Oblast and Kyiv, 8.1% to Lviv Oblast, and 7.2% to Poltava Oblast.

The front-line war regions⁴ were home to 70% of displaced students. In the fully-occupied regions, including Donetsk and Luhansk regions, students were mainly displaced internally and headed towards the center of Ukraine.

Displacement among subgroups. We compared the displacement of students across demographic groups, considering the students’ sex and whether they live in an urban or rural area. In 2022, out of all those registered to take the standardized exam, 46% were male and 54% were female. The male-female ratio among displaced students was similar, with 48% being male and 52% being female.

In Ukraine, urban vs. rural location is often used as a proxy for socioeconomic status. Students living in urban areas generally come from higher-income families and have greater access to financial resources (Skryzhevskaya and Karácsonyi, 2012). Out of all the test takers, 69% of students were from urban areas, versus 31% from rural areas. These groups were impacted disproportionately by displacement: among displaced students, 84% were from urban environments, and 16% from rural areas. Furthermore, among internationally displaced students, 87% were from urban and 13% were from rural areas. We hypothesize that these disparities were likely because urban families had the means to migrate within Ukraine or move abroad, while rural families had fewer options.

Decline in standardized exam participation (drop-off). Standardized exams were *strictly required*⁵ for all students who wished to study at a Ukrainian university. From 2016–2021, students were required to *register* for the exam as a part of their school graduation process, but due to COVID-19 policy changes, there was no requirement to actually *take the exam* in 2020 and 2021. As a result, when studying the decline in exam participation, we focus only on students who *actually took the exam* to provide a more precise (and conservative) estimate. Note that we did not make this distinction when looking at student displacement because we are only interested in *where students registered to take the exam*, not whether they actually took it.

Figure 3 shows the number of students taking the standardized exam in Ukraine from 2017 to 2022. In 2020 and 2021—the two years leading up to the full-scale invasion by Russia—188,511 and 196,927 graduating high school students took the exam, respectively. Notably, the number of students who took the standardized exam during this pre-war period was relatively stable from year to year. In 2022 this number dropped to 155,456, marking a staggering 21% decrease from 2021. For context, the total number of high school graduates in 2022 was 229,000, as seen in Fig. 3a.⁶

Subgroup drop-off. There are also important differences in the number of test takers by subgroup. Differences in exam registration for urban vs. rural students can be seen in Fig. 3b. For graduating students living in the (relatively wealthier) urban areas, the average number of test takers per year over the 2020-2021 period was 130,846, as compared to 108,132 in 2022. For graduating students living in rural areas, the average number of test takers per year over the 2020-2021 period was 61,872, as compared to 47,324 in 2022. Overall, in 2022, the percentage decrease in the proportion of test takers was approximately 20% for urban and 24% for rural students. This disparity is concerning, especially considering the higher poverty rates and lower education levels in rural areas of Ukraine (OECD, 2023b; Skryzhevskaya and Karácsonyi, 2012). For example, the recent global education survey PISA reveals that Ukrainian students in rural areas have an almost five-year learning gap in reading in comparison with their urban counterparts (UNICEF, 2023).

Figure 3c compares the number of male vs. female test takers. From 2020-2021, the average number of male graduating high school students taking the exam was 88,294, (46% of all test-takers). In 2022, that number decreased by 20% to 70,585. For female students, the average number of test takers per year over the 2020-2021 period was 104,425 (54% of all test-takers). In 2022, that number decreased by 19% to 84,871. While the 2022 proportion of male vs. female test takers is only slightly different compared to the years before, it reinforces a problematic trend, where more and more male students dropping off the traditional educational pathway in Ukraine, with 2022 showing a disparity of 10% in the male-to-female ratio.

Intersectionality. Figure 3d shows the percentage break-down of test-takers by intersections between area and sex. We found that the intersectional subgroup most affected by drop-off was rural-males, who made up the smallest percent of overall graduating high school students who took the Ukrainian language arts exam

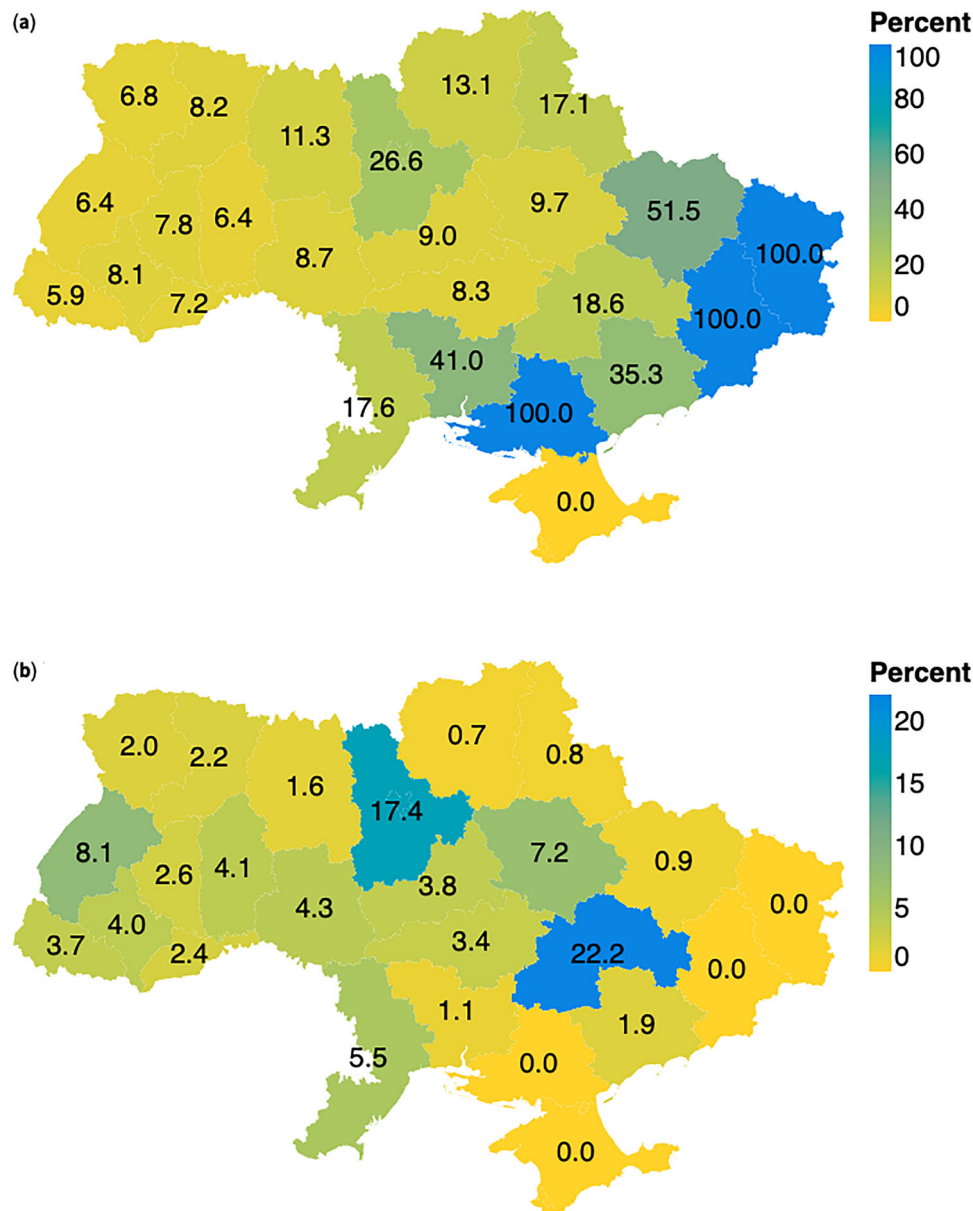


Fig. 2 Maps of student displacement (Origin and Destination). (a) The percentage of graduating high student test takers displaced from each region in 2022. In total, approximately 36,500 test takers were displaced. For each region, the numerator is the number of students who registered in that region but chose to take the exam elsewhere, and the denominator is the total number of students registered in that region. (b) The destinations of the approximately 13,300 graduating high school students displaced within Ukraine in 2022, adding up to 100%.

in 2022 at just 13%. Overall, there was a 7.14% decrease in the number of rural-male test-takers, as compared to 6.25% and 2.17% decreases for the rural and male groups, respectively. Put another way, the impact of the war on drop-off for rural-males was greater than for either test-takers living in rural areas or males, indicating an intersectional disadvantage.

Discussion

Challenges facing Ukraine. This work characterized the scope of two challenges Ukraine will be facing moving forward: the displacement of graduating high school students both within Ukraine and abroad, and student drop-off from the typical educational roadmap.

Our analysis shows that the majority of displaced students migrated abroad to countries including Poland, Germany, and Czechia. Reversing “brain drain”—to the extent it is even possible—is

no easy feat for any country (Zweig, 2006). Further, the issue may be time-sensitive: as the war continues, some families become more deeply rooted in their lives abroad.

Drop-off will also likely have downstream negative effects on enrollment in Ukrainian universities in the coming years, which is compounded by existing enrollment challenges. For example, international exchange programs, which brought 80,000 additional students to Ukrainian universities every year before the war, have been put on hold (Al Gharaibeh et al. 2023). International students were previously drawn to Ukrainian universities for their low cost relative to their academic strength (Al Gharaibeh et al. 2023)—a competitive advantage that could be re-emphasized following the conclusion of the war.

The Ukrainian government has pursued several important education policy initiatives, aimed at minimizing disruptions to the academic year, and at increasing academic opportunities for students in Ukraine.

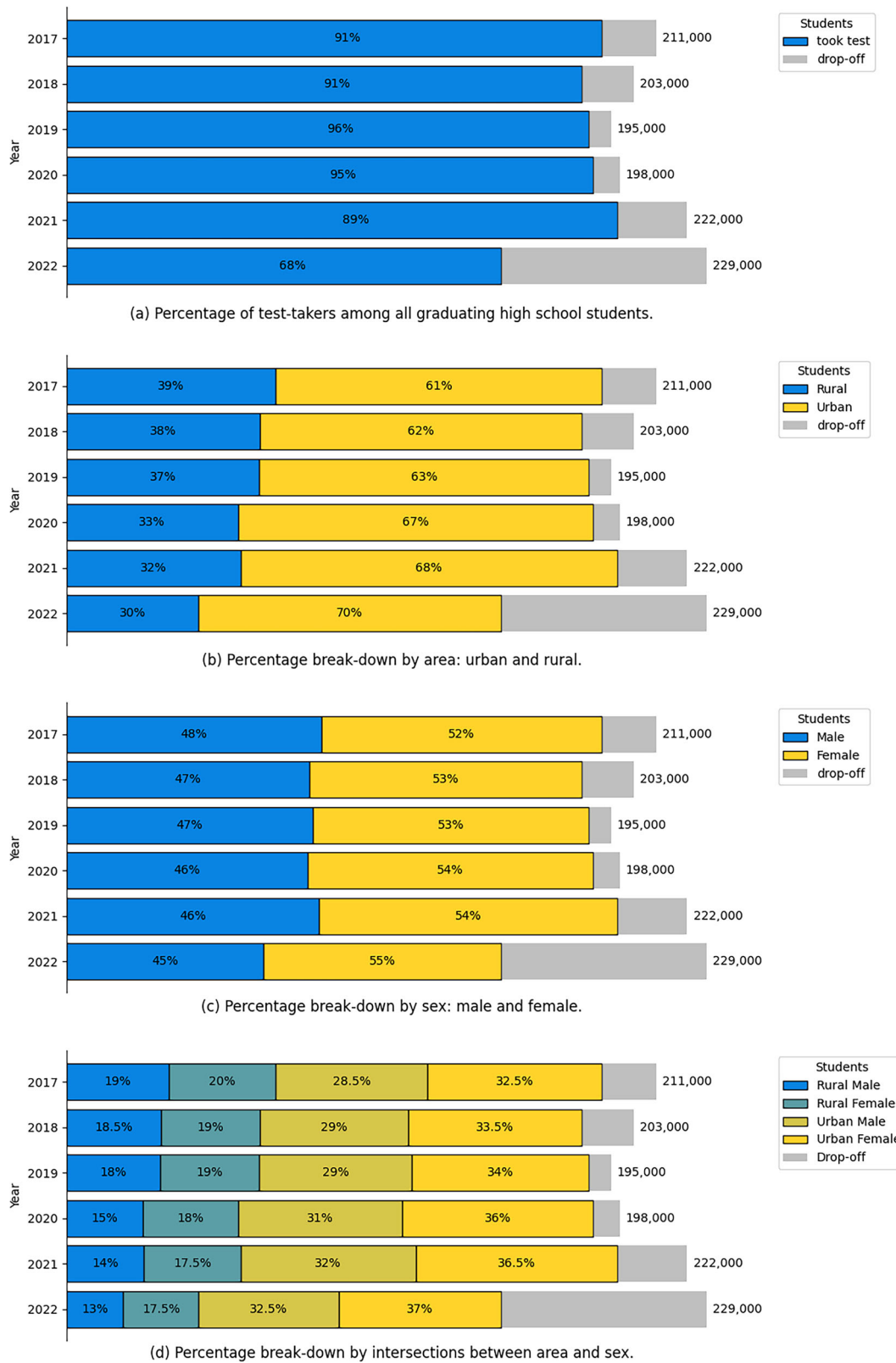


Fig. 3 The number of graduating high school students who took the Ukrainian language arts exam from 2017–2022. **a** Percentage of test-takers among all graduating high school students. **b** Percentage break-down by area: urban and rural. **c** Percentage break-down by sex: male and female. **d** Percentage break-down by interactions between area and sex.

Actions to minimize disruptions of the academic calendar. Ukraine has made a number of policy decisions that aim to maintain the continuity of learning for students as much as possible—an objective that is considered critically important for

educational systems in countries in conflict (Angrist et al. 2022). Immediately following the beginning of the full-scale invasion on February 24, 2022, all schools and universities paused their activities for two weeks. However, following this short period, all

educational institutions resumed activities to the best of their ability, often utilizing remote and online learning (Nenko et al. 2023).

Fully remote schools have now become a critical part of the country's educational infrastructure—for example, Ukraine's first and largest online school, Optima School, is serving 102,000 students.⁷ Another distance education initiative sponsored by the Ukrainian Ministry of Education and Science is "Learning without Borders," where lessons for various middle school and high school subjects are broadcast for free on the national TV for the general public (Malykhin et al. 2022). While remote learning is not without challenges—such as disruptions by air alarms, power outages, and lack of reliable internet access—there is evidence these changes have been successful. It's also worth highlighting the efforts to preserve in-person instruction, even in front-line war regions. For example, in Kharkiv Oblast, schools have been created in underground metro stations (Vox Populi Agency, 2024). A survey of students in the months following the full-scale invasion found that fewer than 15% of them had not attended class over the prior two weeks (Melnyk, 2022).

Another positive example of Ukraine's ability to minimize disruptions of the academic year was their transition from the previously paper-based EIE exam to the computer-based NMT (Nikolaiev et al. 2023). This transition deserves considerable praise: to successfully administer NMT, brand new software had to be developed, implemented, and delivered to hundreds of thousands of students. Three additional positive changes were made to the test-taking process. First, under the EIE, students were required to take the exam over multiple days; while under the NMT, each student can complete their exam in one day. This measure was implemented to improve student security. Second, under the NMT, students receive their results immediately, as opposed to having to wait for weeks as was the case with the EIE.⁸ Third, for the first time ever, the exam was available to students outside of Ukraine in 32 countries around the world. This was made possible with the help of a network of global partners and volunteers, including UNESCO and UNICEF (UNESCO, 2022).

One of the major findings of this work was that participation in the standardized exam has fallen by over 21%. While this is a large percentage, we hypothesize that this decrease would have been even more substantial without the transition to the electronic exam. Notably, the continuation of the standardized exam was important politically: standardized exam reforms over the last decade are seen as one of the most important steps to address corruption in higher education admissions (Klein, 2014).

Initiatives to increase academic opportunities for students.

After the start of the war, many researchers and universities from around the world partnered with Ukrainian institutions to provide academic and research opportunities for students who reside in Ukraine. Oleksiyenko et al. (2023) note the positive, transformative crisis-driven internationalization that has happened in Ukraine. We are aware of more than 10 such programs, detailed in SI Appendix, Table S18. We highlight two of these programs below.

The first is the Responsible AI (RAI) for Ukraine research program, established by the Center for Responsible AI at New York University, in partnership with the Ukrainian Catholic University in Lviv, Ukraine. The stated goals of the program are to provide a sense of normalcy to Ukrainian students, and to give them access to high-quality research experience with international mentors from 10 institutions in the US and Western Europe. Further, the program aims to help build research capacity in Ukraine, both generally in Science, Technology, Engineering, and Mathematics (STEM) and specifically in the critically

important area of RAI.⁹ In total, the program has offered research opportunities to 72 undergraduate and graduate students, including 28 women, from 11 Ukrainian universities. Our research team operates as part of this program, and this research study is among the program's outputs.

The second program is Ukraine Twinning initiative, a partnership between Ukrainian universities and 79 universities in United Kingdom, that formed with the goal to mitigate the disruption of research activities due to the war.¹⁰ The partnership allows Ukrainian students to join scientific research programs and participate in dual-degree programs.

Programs such as these can help create positive experiences for university students in Ukraine, but the challenge is to reach sufficient scale to meet the demand. Further, while offering collaborative research opportunities to university students may help mitigate drop-off, this does not directly benefit high school students.

Psychological impact of war on Ukrainian students. Recent findings indicate that stress may impair the ability to update memories in response to new information, shifting learning from a flexible, cognitively oriented approach to a more rigid, habit-based one (Vogel and Schwabe, 2016). Not surprisingly, Ukrainian students have experienced heightened levels of stress due to the Russian invasion (Goto et al. 2024; Melnyk et al. 2024; Abdusamatov et al. 2025; Kurapov et al. 2024).

A large cross-sectional study of more than 8,000 Ukrainian adolescents (aged 15 or older, attending secondary school either in person or online) found that exposure to war significantly increased the likelihood of clinically significant levels of depression, anxiety, and substance use risk (Goto et al. 2024). Specifically, nearly one-third of participants reported moderate or severe depressive symptoms, over one-third experienced clinically significant trauma, and these mental health burdens persisted even among adolescents residing abroad.

Moreover, research indicates that displaced Ukrainian students—whether internally or externally—experience distinct mental health outcomes compared to those who remained in regions without active conflict (Melnyk et al. 2024). Additional studies, including a mixed-methods analysis of 500 migrant students and 50 in-depth interviews with educators and experts, highlight how legal, psychological, and economic barriers substantially undermine migrant students' educational success (Abdusamatov et al. 2025).

These findings underscore the urgent need for social and psychological support measures for all students affected by war—a need that remained largely unmet during the summer of 2022, when students first took the NMT exam. Our work helps quantify the extent of displacement and can inform the design of such support measures.

Conclusion

Since declaring independence from the Soviet Union in 1991, setbacks in Ukraine have come hand-in-hand with its achievements (Diuk, 2001). Russia's full-scale invasion that started in early 2022 and continues to this day is no exception—Ukraine's institutions and its people have shown incredible resilience and heroism in a time of crisis. In this work, we explore the impact of the war on the displacement of graduating Ukrainian high school students, and on their drop-off from the traditional educational pathway. Our analysis is based on a uniquely comprehensive dataset of standardized exam outcomes for admissions to higher education institutions in Ukraine. Like any secondary data analysis, our work comes with limitations, most notably, that we cannot use it to make inferences about student performance across years. Our findings have important implications for

governmental organizations like the Ukrainian government and the European Union, and human rights organizations like the United Nations Refugee Agency and the International Organization for Migration, by informing their crucially important work of mitigating and recovering from the impacts of the war on the country's education system. Our hope is that, with the help of the international community, Ukraine will be able to build back even stronger.

Data availability

Data for this study was obtained from the publicly available open data resource of the Ukrainian Center for Educational Quality Assessment (UCEQA), published at <https://zno.testportal.com.ua/opensource>. The Law of Ukraine, "On Access to Public Information," <https://zakon.rada.gov.ua/laws/show/2939-17#Text> governs the collection, publication, and usage of this data. Under this law, information administrators are obliged to provide public information as open data upon request, publish it, and regularly update it on the unified governmental open data web portal and their websites. Any party may freely copy, distribute, and use these datasets (including for commercial purposes) with appropriate attribution. Furthermore, all personal identifiers have been removed from the data (i.e., data has been deidentified) in accordance with the Law of Ukraine "On Personal Data Protection," https://ips.ligazakon.net/document/view/t102297?an=227&ed=2025_01_18, ensuring that no sensitive information about individuals is publicly disclosed. We enriched and processed this data to facilitate analysis. All data and data cleaning code are available at <https://github.com/DataResponsibly/ZNO-Dataset>.

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Notes

- 1 Data can be accessed at <https://zno.testportal.com.ua/opensource>.
- 2 <https://ukrstat.gov.ua/>.
- 3 https://ukrstat.gov.ua/druk/publicat/kat_u/2023/05/zb_vrp_2021.xlsx.
- 4 We define front-line regions as those that have been at least partially occupied or subjected to intense bombardment in March 2022. These include Donetsk, Luhansk, Zaporizhzhia, Kyiv, Mykolaiv, Sumy, Kharkiv, Kherson, Chernihiv regions, and the city of Kyiv.
- 5 There is a small number of exceptions, like persons with certain disabilities.
- 6 <https://ukrstat.gov.ua/>.
- 7 <https://optima.school/>.
- 8 In part, this was made possible by removing the free-response questions from the exam.
- 9 <https://r-ai.co/ukraine>.
- 10 <https://www.twinningukraine.com/>.

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Author contributions

All authors contributed to all parts of the work on this paper, including ideation, data analysis, and writing. • Tetiana Zakharchenko (co-first author) contributed to ideation, data preparation, data analysis, and to writing. This included implementing data processing code and preparing documentation. • Andrew Bell (co-first author) contributed to ideation, data analysis, and writing and reviewing the manuscript, and reviewing the

data processing code and documentation. • Nazarii Drushchak contributed to ideation, data preparation, and data analysis. This included writing data processing code and preparing documentation. • Oleksandra Konopatska contributed to ideation, reviewing, data preparation, and data analysis. • Falaah Arif Khan contributed to ideation, writing and reviewing. • Julia Stoyanovich (senior author) contributed to ideation, data analysis, writing and reviewing the manuscript, and reviewing the documentation.

Competing interests

The authors declare no competing interests.

Ethical approval

This article does not contain any studies with human participants performed by any of the authors. Because this article is based on secondary analysis of public data, ethical approval was neither required nor obtained.

Informed consent

This article does not contain any studies with human participants performed by any of the authors. Data for this study was obtained from the publicly available open data resource of the Ukrainian Center for Educational Quality Assessment (UCEQA), published at <https://zno.testportal.com.ua/opendata>. The individuals whose records appear in these datasets were informed of data collection and usage through the official procedures governing External Independent Evaluation (EIE) or National Multi-subject Test (NMT), as mandated by the Ministry of Education and Science of Ukraine. Specifically, the public order states: "The fact of receiving the registration card at the processing point is the basis for processing personal data in the process of preparing and conducting external independent evaluation ... in accordance with the requirements of the Law of Ukraine 'On Personal Data Protection'." By submitting registration documents or providing information through the Information and Communication System for the NMT, participants gave their consent for the collection and use of their data. As a result, the published, deidentified datasets from UCEQA are legally permitted for unrestricted research and dissemination purposes in compliance with Ukrainian legislation.

Additional information

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