Design aspects of virtual patient collections for learning clinical reasoning in times of war

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Eidesstattliche Versicherung und Erklärung

Hiermit versichere ich an Eides statt, dass die vorliegende Dissertation von mir selbständig und ohne unerlaubte Hilfe angefertigt wurde. Zudem wurden keine anderen als die angegebenen Quellen verwendet. Außerdem versichere ich, dass die Dissertation keiner anderen Prüfungskommission vorgelegt wurde und ich mich nicht anderweitig einer Doktorprüfung ohne Erfolg unterzogen habe.

Statutory declaration and statement

I declare that I have authored this thesis independently, that I have not used other than the declared sources/resources. As well I declare that I have not submitted a dissertation without success and not passed the oral exam. The present dissertation (neither the entire dissertation nor parts) has not been presented to another examination board.

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List of abbreviations

CR	Clinical reasoning
iCoViP	International Collection of Virtual Patients
VP	Virtual patient
WHO	World Health Organization

1. List of publications

This cumulative dissertation is a summary of the following two publications.

Publication 1

Mayer A, Da Silva Domingues V, Hege I, Kononowicz AA, Larrosa M, Martínez-Jarreta B, Rodriguez-Molina D, Sousa-Pinto B, Sudacka M, Morin L. Planning a collection of virtual patients to train clinical reasoning: a blueprint representative of the European population. IJERPH 2022;19(10):6175.

Publication 2

Mayer A, Yaremko O, Shchudrova T, Korotun O, Dospil K, Hege I. Medical education in times of war: a mixed-methods needs analysis at Ukrainian medical schools. BMC Med Educ 2023; 23(1):804.

2. Contributions to the individual publications

My contribution to each publication will be outlined as follows:

Publication 1

I developed and implemented a four-step approach to create a blueprint for a diverse and realistic VP collection, defining key symptoms, diagnoses, and contextual factors (e.g., age, gender). It was my responsibility to coordinate and monitor this iterative process, to compare VP characteristics with reference values from the literature, WHO, and Eurostat, and to initiate refinements. For the final diagnoses, I conducted a modified Delphi approach with the international project partners to define which ones should be included in the blueprint. After consensus on the final blueprint was reached with all project partners, I conducted a descriptive analysis of the VP characteristics. I wrote the first draft of the manuscript under the supervision of Dr. Inga Hege and Dr. Luc Morin and produced all the figures and tables. I then coordinated discussions on the manuscript with the project partners, revised the manuscript accordingly, and was responsible for submitting the final version, handling all correspondence with the journal, and making the necessary revisions in the two rounds of peer review that followed.

Publication 2

I designed the study and developed the survey questions and interview guideline in collaboration with the research team. It was my responsibility to gain the approval of the IRB at LMU Munich, to implement the survey on the platform LimeSurvey, and to pilot it. I conducted a descriptive analysis of the population characteristics and the closed-ended survey questions and created the corresponding tables for the manuscript. For the open-ended survey questions and the interview transcripts, I conducted a qualitative content analysis together with Dr. Olena Yaremko and Dr. Inga Hege and integrated the feedback of the reviewing co-authors. I then created a thematic map of the identified themes and drafted the manuscript under the supervision of Dr. Inga Hege. Finally, I coordinated the review of the manuscript with all co-authors. I was responsible for submitting the final version, handling all correspondence with the journal, and responding to comments by the editor and reviewers.

3. Introduction

In recent years, the use of online and blended teaching and learning has increased in medical education (1) and it has become even more important in times of recent crises such as war or the COVID-19 pandemic.

In times of war, it is crucial to maintain the quality of medical education to meet the challenges of healthcare (2, 3). However, any war is a threat to education in general (4, 5) as well as to the education of healthcare professionals (6). One of the latest examples of war is the Russia-Ukraine conflict, which started on February 20th, 2022. Since then, Ukraine has been facing challenges in medical education, such as students and educators fleeing the war or serving on the front lines (7, 8), students delaying their studies, missing important learning objectives, or dropping out (9, 10).

Online teaching is one possible solution to maintain education in times of crisis, for example, using video conferencing, videos, or virtual patients (VPs) to simulate, at least to some extent, patient encounters, since access to patients is often extremely restricted during such times. VPs are computer-based patient case scenarios that provide a safe environment in which learners can work on a case without time pressure and are allowed to make mistakes without fear of harming a patient (11).

In particular, VP collections can help medical schools to better adapt to challenges such as the COVID-19 pandemic, when medical schools worldwide were forced to rapidly convert their curricula to online formats and educators were challenged to teach their students remotely with very limited access to patients (12). For example, a publicly available VP collection experienced a tenfold increase in usage as countries around the world requested VPs, and case authors were challenged to quickly provide COVID-19-related VPs (13).

Recent studies suggest that VPs are an appropriate method for training clinical reasoning (CR) (14), i.e., the process of gathering patient data, weighing options, reaching a final diagnosis and developing a treatment plan (15). As novices need to experience many cases to become experts (16), VPs are usually provided as part of a collection. To promote CR, such VP collections should allow for deliberate practice and comparing and contrasting of similar cases (15, 17). Therefore, the careful design of a VP collection is

a crucial aspect for learning CR, but is often neglected in the development of digital collections (18). Previous studies have shown that existing VP or case collections mainly contain prototypical scenarios and are not representative of the real world in terms of key symptoms, diagnoses, and contextual factors such as age, ethnicity, or sexual orientation (19–21). Although some guidance for the creation of individual VPs can be found in the literature (22, 23), there is little sophisticated approach to planning realistic and diverse VP collections.

Consequently, in April 2021, the Erasmus+-funded project iCoViP (International Collection of Virtual Patients) (24) was launched by an interdisciplinary consortium of researchers, educators, and physicians from five European countries (France, Germany, Poland, Portugal, Spain). The aim of this project was to plan and create a diverse and realistic collection of 200 VPs that would facilitate deliberate practice of CR and meet the needs of the involved medical schools. To achieve this goal, the project included the following steps:

1) Development of a blueprint to define key symptoms, diagnoses, and contextual factors (e.g., age, gender, sexual orientation) for 200 VPs
2) Creation of the 200 VPs and translation into six languages
3) Pilot implementation of the VPs at the medical schools of the project partners and at associated medical schools worldwide
4) Development of a guideline on how to integrate the VP collection into a medical curriculum in virtual or blended-learning scenarios

The blueprint, the VP collection, and the integration guideline are freely available (25).

After the outbreak of the Russo-Ukrainian war, educators from Ukraine translated the VPs of the iCoViP project and implemented them into the curricula of Ukrainian medical schools (26, 27).

4. Research questions

The overall aim of this doctoral thesis was to explore aspects that need to be considered when designing VP collections for learning CR in general, and further to analyze the specific needs in times of war as a basis for using such a collection to overcome the associated lack of patient encounters to some extent. Therefore, I worked on the following two research questions:

1) What are suitable methods and steps in the planning process for a diverse and realistic VP collection that facilitates deliberate practice of CR and meets educational requirements of medical schools in Europe?

2) What are the specific effects of the ongoing Russo-Ukraine war on medical education and its stakeholders in Ukraine, the resulting needs, and the expected consequences?

5. Abstracts of publications

5.1 Abstract of publication 1

Background: Virtual patients (VPs) are a suitable method for students to train their clinical reasoning abilities. We describe a process of developing a blueprint for a diverse and realistic VP collection (prior to VP creation) that facilitates deliberate practice of clinical reasoning and meets educational requirements of medical schools.

Methods: An international and interdisciplinary partnership of five European countries developed a blueprint for a collection of 200 VPs in four steps: (1) Defining the criteria (e.g., key symptoms, age, sex) and categorizing them into disease-, patient-, encounter- and learner-related, (2) Identifying data sources for assessing the representativeness of the collection, (3) Populating the blueprint, and (4) Refining and reaching consensus.

Results: The blueprint is publicly available and covers 29 key symptoms and 176 final diagnoses including the most prevalent medical conditions in Europe. Moreover, our analyses showed that the blueprint appears to be representative of the European population.

Conclusions: The development of the blueprint required a stepwise approach, which can be replicated for the creation of other VP or case collections. We consider the blueprint an appropriate starting point for the actual creation of the VPs, but constant updating and refining is needed.

5.2 Abstract of publication 2

Background: As Ukraine struggles with the education of healthcare professionals due to the war, we aimed to identify the specific effects of the war on medical education, the resulting needs, and the expected consequences for schools, faculty, staff, students, and the healthcare system.

Methods: In October and November 2022, we performed a survey of students, faculty, and staff of medical schools in Ukraine and conducted semi-structured interviews with faculty leaders (i.e., rectors, vice-rectors). We conducted a descriptive analysis of the survey's closed-ended questions. The survey and the interviews included open-ended questions about war-related restrictions to teaching and learning, resulting needs, and expected consequences, for which we applied a thematic analysis.

Results: We received 239 survey responses (N=49 faculty and staff, N=190 students) and conducted nine interviews with faculty leaders across Ukraine. Most survey participants indicated that they had experienced restrictions or changes to their work or study due to the war (86% of faculty and staff, 69% of students). From the thematic analysis of the survey and interviews, we identified eight themes: disruption of teaching, increased workload, mental stress, financial restrictions, non-war related needs, international cooperation, quality of education, and prospects of future professionals. The quality of healthcare education in Ukraine was threatened, and schools, faculty, staff, and students were under great strain. While already established international cooperation has been supportive, some needs have still not been addressed.

Conclusions: We hope that our findings will help researchers and educators from abroad contribute to meeting Ukraine's needs in medical education.

6. Discussion

6.1 Summary of methods

To develop a reusable process and a blueprint with patient characteristics for creating a VP collection, a modified Delphi approach was used, which is common in medical education research (28) and has been used internationally in curriculum planning (29, 30). The process considered various criteria and contextual factors, as well as the opinions and needs of medical educators and researchers from five different countries. I then compared our blueprint with reference values from European data sources and implemented several rounds of feedback until all partners of the iCoViP project reached consensus on the blueprint.

For the following needs analysis, a mixed-methods approach was applied, performing a survey among faculty, staff, and students at Ukrainian medical schools and conducting interviews with faculty leaders (i.e., rectors and vice-rectors of medical schools). The responses to the closed-ended questions of the survey were analyzed descriptively. The responses to the open-ended questions of the survey and the transcripts of the interviews were subjected to a qualitative content analysis, following the inductive approach suggested by Kuckartz (31).

6.2 Discussion of methods

From a methodological point of view, the work presented in this doctoral thesis has several strengths.

First, to develop the blueprint for our VP collection, we did not rely on randomized data, as was done in a previous project (32), but used a modified Delphi approach, several assessment steps, and group discussions to reach consensus. In doing so, the Delphi approach proved to be a highly suitable method for reaching consensus in our diverse group.

Second, a mixed-methods approach was used to conduct the needs analysis at Ukrainian medical schools, including open-ended and closed-ended questions. Triangulation of data sources and measures was achieved by involving the key stakeholders in medical education and performing a survey as well as semi-structured interviews. This allowed me to explore broad perspectives and strengthened the validity of the findings (33).

6.3 Summary of results

The study shows that a four-step approach combined with a modified Delphi method can support educators in planning a balanced and diverse VP collection to train CR. The result of this process is a detailed blueprint for 200 VPs, which covers 29 key symptoms and 176 final diagnoses. The selected diagnoses not only meet the needs of the involved medical schools, but also allow students to train CR by comparing and contrasting similar case features. In addition, the blueprint can be considered representative of the European population in terms of most of the contextual factors included (i.e., age, gender, sexual orientation, migration background, substance abuse). Based on this blueprint, the 200 VPs have been created as part of the iCoViP project and translated into English, French, German, Polish, Portuguese, Spanish, and Ukrainian, and are being used in various medical schools across Europe. As a result, the project achieved a very broad value creation, culminating in the adoption of the product to support Ukrainian medical schools reduce the impact of missing patient encounters during the war.

I was also able to show that the quality of medical education in Ukraine was threatened by the disruption of teaching, financial restrictions, increased workload, and mental stress, all of which were caused by the war and had a negative impact on students' learning. Problems that had existed before the war, such as the lack of practical training in the curricula or the need for modern teaching resources, exacerbated in the situation of war. In addition, the prospects of future medical professionals in Ukraine were considered extremely negative. While some needs were being met by already established international collaborations, other needs remained unmet, such as substitute for patient encounters and more digital learning resources. Most participants (86% of faculty and staff, 69% of students) reported restrictions or changes in their work or studies due to the war. A high proportion of faculty members and students had experience with online teaching formats, such as lectures (67% and 63%) or workshops (71% and 65%).

6.3 Discussion of results

By involving project partners from different medical and scientific backgrounds in the development of the blueprint, the perspectives of physicians, researchers, educators, as well as other healthcare professionals across Europe were considered, similar to previous international projects (34, 35). We ensured that our VP collection would be applicable and integrable into the curricula of European medical schools, for example by considering cultural differences, as was recommended by Fors et al. (36). Despite our best efforts, the proportions of some patient characteristics did not reach the reference values, for example regarding professions and disability. However, compared to previous projects, our VP collection proved to be more diverse and realistic in terms of European society (20, 21). Our consortium considered the final blueprint to be a good starting point but is aware of the need to further expand the collection in the future.

The threats to medical education in Ukraine that was identified through the needs analysis were consistent with those of the scoping review by Dobiesz et al. (37), which focused on barriers and targeted interventions to sustain healthcare education in times of war. However, additional themes were found in this study. These included worse prospects of future professionals, such as negative expectations of poorer working conditions and an increased workload in the future, which are largely consistent with recent publications (38, 10). While similar studies from Iraq found that most students were willing to leave the country (39, 40), this finding was not present in our data. This is likely because, at the time of data collection, participants had been living under war conditions for eight months, rather than many years, as was the case in Iraq. In fact, the timing of data collection makes our study unique, as similar studies have been conducted retrospectively or after several years of ongoing war (41, 42).

Due to frequent air raid alerts, online teaching was inevitable to maintain medical education in Ukraine, facing challenges such as lack of devices, limited access to platforms and internet blackouts, as described in other recent publications (43–45). A major consequence of air raid alerts was limited access to patients throughout the country, as many hospitals did not have enough shelters to keep patients, staff, and students safe in the event of air raids. Students were also prevented from patient encounters due to dangerous traveling conditions, or when healthcare facilities nearby were destroyed and rendered unusable. In addition, many students who had fled their homes were able to

continue their studies online but did not have access to hospitals where they were staying. This, and the fact that participants had expressed their wish for simulations and digital teaching resources, showed the need and opportunity to implement VPs into medical curricula in Ukraine. The use of VPs for training CR could also help graduates who are faced with limited access to patients to feel more competent and have a positive impact on their future professional development.

Therefore, the 200 VPs, that were created based on the blueprint, were translated into Ukrainian and have been implemented in 14 medical schools in Ukraine (27). Educators from these medical schools were trained in the use of VPs and, based on the blueprint and the integration guideline of the iCoViP project, they selected VPs for their students and integrated them into their respective curricula. Evaluation results among students showed that they enjoyed working on VPs and were highly motivated to continue with it. Furthermore, the application of the VPs to the Ukrainian context was straightforward and except for the translation no adaptations were necessary. This again shows that our careful planning of the VP collection was successful, providing proof for our concept.

Among other things, the needs analysis showed the need for new teaching methods, digital resources, and substitute for patient encounters. Therefore, our VPs and the corresponding train-the-trainer courses can be seen as an answer to these needs. Thus, the VPs from the iCoViP project are not only being used in medical schools throughout Ukraine but will also serve as the basis for further cooperation in the future.

6.4 Limitations

Despite the careful design of the studies, there are a few limitations.

In publication 1, the blueprint was compared with sources of population statistics to ensure that the collection was realistic in terms of patient characteristics at the international level. However, as no specific data sources on the European patient population were available, we had to rely on data based on the general population in Europe, such as from WHO or Eurostat. Still, although our VP collection may not be perfectly representative of the European patient population, we have managed to create a more diverse and realistic collection than those described in previous literature (19, 46).

In publication 2, many participants reported frequent power blackouts and an unstable internet connection, which was due to the fact that the Russian Federation began attacking the energy infrastructure throughout Ukraine on the same day we sent out the survey (47). This could be seen as a limiting factor for online teaching in general, but also for implementing VPs. However, the situation in Ukraine has continued to change, and the problems described have been intermittent rather than persistent.

6.5 Conclusions and outlook

With the work presented in this doctoral thesis, I was able to show how a VP collection can be developed, considering various criteria for content and involving researchers, educators, and physicians from different countries in the process. Furthermore, I found that the VPs of the iCoViP project addressed some of the war-related needs of medical education in Ukraine and were a valuable resource to maintain medical education. On the other hand, outdated and teacher-centered teaching methods have been part of pre-war Ukrainian medical education. Thus, VP collections designed for CR training can support the evolution of Ukraine's medical education towards more learner-centered and case-based teaching. These teaching approaches have been shown to be superior to traditional methods not only in the acquisition of factual and practical knowledge, but also in the stimulation of self-regulated learning (48–50). In turn, self-regulated learning can be a powerful tool for maintaining medical education when educators are scarce or overworked, or teaching is disrupted. To promote the transition to more case-based teaching in Ukraine, train-the-trainer courses have already been established in a further project (27), using the translated VPs of iCoViP. As a next step, this project is supporting Ukrainian educators in a cultural shift towards a more learner-centered approach.

Since the beginning of the COVID-19 pandemic, violence and armed conflicts have increased world-wide. By 2030, 59% of the world's poorest people are expected to live in countries affected by violence, conflict, or fragility (51). Also, the advancing climate crisis is predicted to increase the likelihood of not only natural disasters but also pandemics and armed conflicts (52, 53). Medical schools should be prepared for such events, as they affect the morbidity and mortality of large parts of a country's population (54). The associated migratory flows can lead to rapid changes in the patient characteristics of a country so the methodology developed in publication 1 may be a useful tool to meet

future needs and adapt existing VP collections. The Russo-Ukrainian war is a recent example, resulting in 1.1 million Ukrainian refugees arriving in Germany in 2022, of whom about 700,000 arrived within the first three months of the war (55).

7. Summary

7.1 Summary

In recent years, the use of online teaching methods in medical education has increased, and in times of recent crises such as war or the COVID-19 pandemic, it is becoming even more important. Online teaching is one way to maintain medical education in times of crisis, and virtual patient (VP) collections are a suitable tool to train clinical reasoning (CR) in an online environment when access to patients is limited. Although careful planning of a VP collection is a crucial aspect, it is often neglected in the development of digital collections. Therefore, the Erasmus+ project iCoViP (International Collection of Virtual Patients) was launched in 2021 to plan and deliver a multilingual collection of 200 VPs. After the outbreak of the Russo-Ukrainian war, the VPs were translated into Ukrainian and implemented at 14 Ukrainian medical schools, as an extension to the project.

As part of the iCoViP project, this doctoral thesis aimed to develop a methodology for designing realistic VP collections for learning CR and to identify the current needs of students, faculty, and staff of medical schools in Ukraine.

In publication 1, I proposed a four-step approach, including a modified Delphi approach, that can support educators in planning a balanced VP collection to train CR. In publication 2, I found that the quality of medical education in Ukraine was threatened due to the war because of disruption of teaching, financial restrictions, increased workload, and mental stress. As a result, among other things, there was an unmet need for more practical training and modern teaching resources.

The VP collection of the iCoViP project can be considered representative of the European population and has been implemented at Ukrainian medical schools without the need for any adaptations. By implementing the VPs, we have been able to meet some of the needs of medical education in Ukraine, such as substitute for patient encounters, or more case-based and learner-centered teaching methods.

7.2 Zusammenfassung

In den letzten Jahren hat der Einsatz von Online-Lehre in der medizinischen Ausbildung zugenommen, und in Zeiten aktueller Krisen wie Krieg oder der COVID-19-Pandemie gewinnt sie noch mehr an Bedeutung. Online-Lehre ist eine Möglichkeit, die medizinische Ausbildung in Krisenzeiten aufrechtzuerhalten, und Sammlungen virtueller Patientinnen und Patienten (VP) sind ein geeignetes Instrument, um medizinische Entscheidungsfindung in einer Online-Umgebung zu üben, wenn der direkte Kontakt zu Patientinnen und Patienten eingeschränkt ist. Obwohl die sorgfältige Planung einer VP-Sammlung entscheidend ist, wird sie bei der Entwicklung digitaler Sammlungen oft vernachlässigt. Daher wurde 2021 das Erasmus+-Projekt iCoViP (International Collection of Virtual Patients) ins Leben gerufen, um eine mehrsprachige Sammlung von 200 VPs zu planen und zu erstellen. Als Erweiterung des Projekts wurden die VPs nach dem Ausbruch des Ukraine-Kriegs ins Ukrainische übersetzt und an 14 medizinischen Hochschulen in der Ukraine eingesetzt.

Als Teil des iCoViP-Projekts zielte diese Doktorarbeit darauf ab, eine Methode für die Planung realistischer VP-Sammlungen zum Erlernen medizinischer Entscheidungsfindung zu entwickeln und die spezifischen Bedarfe von Studierenden, Lehrenden und Mitarbeitenden medizinischer Hochschulen in der Ukraine zu ermitteln.

In Publikation 1 habe ich einen vierstufigen Ansatz, einschließlich eines modifizierten Delphi-Verfahrens, beschrieben, der Lehrende bei der Planung einer ausgewogenen VP-Sammlung zum Erlernen der medizinischen Entscheidungsfindung unterstützen kann. In Publikation 2 fand ich heraus, dass der Krieg die Qualität der medizinischen Ausbildung gefährdete durch Unterbrechung der Lehre, finanzielle Einschränkungen, erhöhte Arbeitsbelastung und psychische Belastung der Beteiligten. Dies hatte unter anderem zur Folge, dass Bedarf an mehr praktischen Tätigkeiten und modernen Lehrmitteln bestand.

Die VP-Sammlung des iCoViP-Projekts kann als repräsentativ für die europäische Bevölkerung angesehen werden und so war es möglich, sie direkt an medizinischen Hochschulen in der Ukraine einzusetzen. Durch die VPs konnten wir die medizinische Ausbildung vor Ort entsprechend einiger der ermittelten Bedarfe unterstützen; so dienten die VPs als digitaler Ersatz für direkten Kontakt zu Patientinnen und Patienten und ermöglichten mehr fallbasierte und lernendenzentrierte Lehre.

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Planning a Collection of Virtual Patients to Train Clinical Reasoning: A Blueprint Representative of the European Population

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Abstract: Background: Virtual patients (VPs) are a suitable method for students to train their clinical reasoning abilities. We describe a process of developing a blueprint for a diverse and realistic VP collection (prior to VP creation) that facilitates deliberate practice of clinical reasoning and meets educational requirements of medical schools. Methods: An international and interdisciplinary partnership of five European countries developed a blueprint for a collection of 200 VPs in four steps: (1) Defining the criteria (e.g., key symptoms, age, sex) and categorizing them into disease-, patient-, encounter- and learner-related, (2) Identifying data sources for assessing the representativeness of the collection, (3) Populating the blueprint, and (4) Refining and reaching consensus. Results: The blueprint is publicly available and covers 29 key symptoms and 176 final diagnoses including the most prevalent medical conditions in Europe. Moreover, our analyses showed that the blueprint appears to be representative of the European population. Conclusions: The development of the blueprint required a stepwise approach, which can be replicated for the creation of other VP or case collections. We consider the blueprint an appropriate starting point for the actual creation of the VPs, but constant updating and refining is needed.

Keywords: clinical reasoning; medical education; international collaboration; virtual patients; case-based learning; open educational resources

1. Introduction

Virtual patients (VPs) are "interactive computer simulation[s] of real-life clinical scenarios for the purpose of medical training, education, or assessment" [1]. Their importance has been increasing over the years [2], especially since the beginning of the COVID-19 pandemic [3]. VPs provide a safe environment in which learners can work at their own

pace and learn from errors without harming a patient [4]. They are typically designed to unfold in a step-by-step manner, revealing the information about a patient over time leading the learner to the final diagnosis [5,6]. During the process, multimedia elements add authenticity to the VP scenario. Overall, several studies indicated that VPs have the potential to train students in clinical reasoning [7–9].

Clinical reasoning is a complex process in which healthcare professionals (e.g., physicians, physiotherapists, nurses) gather and interpret information, generate hypotheses, derive a final diagnosis, and develop treatment plans [10]. VPs demonstrated their effectiveness in improving components of clinical reasoning such as data gathering, generating differential and final diagnoses, and developing a treatment plan [11,12]. However, this process is not only influenced by medical knowledge, but, according to situativity theory, also by contextual factors related to the patient and to the encounter [13,14]. Such factors can be the setting (e.g., emergency room, general practice), or the patient's age, sexual orientation, comorbidities [15], or behavior [5].

Therefore, providing a collection of VPs to medical students offers the potential for deliberate training of clinical reasoning, but the careful selection of these contextual factors, key symptoms, and diagnoses is crucial [16,17]. Such a balanced selection of key symptoms and (differential) diagnoses in a VP collection prepares students for situations they are likely to experience in practice [18]. Moreover, it enables them to train clinical reasoning by comparing and contrasting, i.e., when they face cases with similar clinical findings, they have to weigh different options based on the relative probability of each diagnosis and the typicality of findings [10,19]. Deliberately varying contextual factors and including atypical presentations influences the complexity of a VP [10,19]. Furthermore, contextual factors are important to create realistic and authentic scenarios [20] that represent the diversity of a patient population adequately. An under- or non-representation of marginalized groups holds the danger of an unintended hidden curriculum [21]. i.e., unintended messages that can bias students, who for example might be subconsciously trained to perceive patients that are male, heterosexual, white, and cis (i.e., the opposite of transgender) as the standard patients in Western countries [22–24].

However, previous studies showed that existing VP or case collections tend to represent the real world only to a limited extent in terms of key symptoms, diagnoses, and contextual factors [24–26]. For example, one case collection [25] scarcely included patients with a disability, migration background, or chronic conditions despite their worldwide relevance in healthcare [27]. Although resources and didactical advice for the creation of individual VPs are available [18,28], there is hardly any guidance for designing a collection of VPs. Previous VP collections [29] and projects such as [30,31] did either not follow or publish a sophisticated planning approach.

To address this shortcoming on an international level, we formed an interdisciplinary partnership of six institutions from Poland, Germany, Spain, Portugal, and France. In our project, iCoViP (international Collection of Virtual Patients) [32], we aimed at planning and delivering a diverse and realistic VP collection that facilitates deliberate practice of clinical reasoning and meets educational requirements of medical schools in Europe. Therefore, our objectives were to develop and assess a reusable process that helps medical educators plan or evaluate VP collections ensuring that they are

(1) realistic in terms of patient characteristics in Europe,
(2) aligned to educational objectives of medical curricula in Europe to ease curricular integration, and
(3) suitable to train clinical reasoning by comparing and contrasting similar cases in varying contexts.

2. Materials and Methods

Due to the lack of guidance on how to implement such a process, we based our planning on our experience from previous projects [25,30,31] and developed a four-step approach to create the blueprint for our VP collection (see Figure 1). Consequently, this

blueprint will serve as the basis for the subsequent VP creation. As agreed upon in the grant proposal of the project, we aimed at creating 125 new VPs to extend an existing collection of 75.

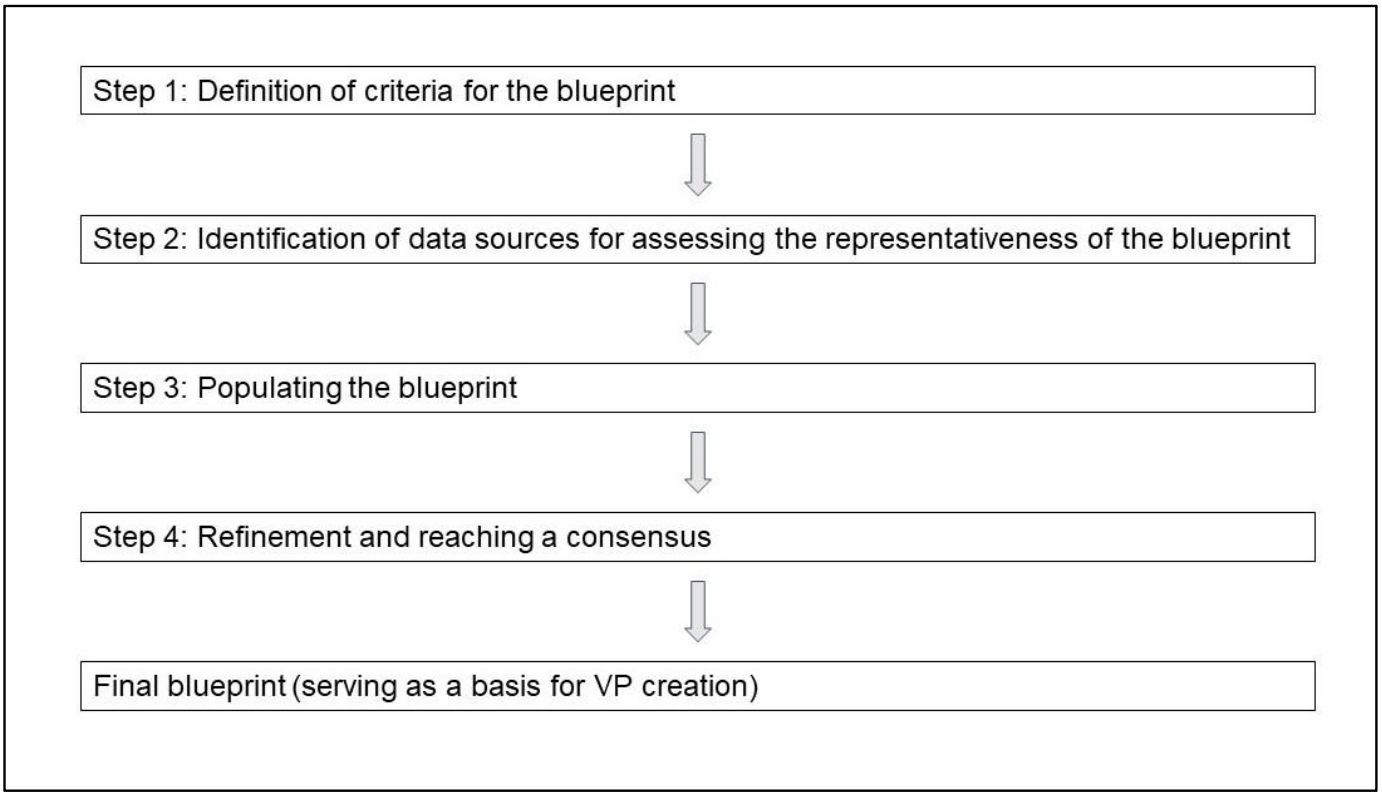

Figure 1. Flowchart of our four-step approach to create the blueprint. (VP = Virtual patient).

Step 1: Definition of criteria for the blueprint

As a first step, we defined the criteria, i.e., variables which needed to be specified for all VPs. We started by extracting criteria from the literature and the experience of our consortium to describe the VPs in the blueprint. Afterwards, we discussed these criteria with all partners and grouped them into (i) disease-related, (ii) patient-related, (iii) learner-related, and (iv) encounter-related criteria, which can be briefly described as followed:

(i) Disease-related: These criteria include the final diagnoses and key symptoms, i.e., the complaints that are the primary reasons for the VPs' visit. This ensures that our collection will cover the most common diseases and symptoms as the main aspects of the clinical reasoning process. We mapped the final diagnoses to the Medical Subject Heading (MeSH) [33] and the national competency frameworks of partner countries which describe the learning outcomes to be covered by medical schools [34–38]. The mapping with the intended learning outcomes and a standard biomedical thesaurus like MeSH facilitates a curricular integration of VPs covering specific learning objectives. Additionally, we clustered the final diagnoses in disease groups based on their pathogenetic pathway, similarly to the VINDICATE approach used in medical education [39]. We also agreed on covering the onset of the disease, e.g., acute, or chronic, to adequately represent the importance of chronic diseases [27] and avoid their underrepresentation. Finally, we included the closure of the scenario, i.e., whether a patient dies or is successfully discharged, to provide a realistic outcome and avoid tabooing the dying of patients.

(ii) Patient-related: These criteria are the VPs' characteristics, including their age, sex, sexual orientation, profession, ethnicity, cultural or migration background, disability, and addiction/substance abuse. These aspects are crucial to ensure a diverse and authentic pa-

tient population [24,25] and to raise awareness for common biases in the clinical reasoning process [40–42].

(iii) Learner-related: We included the role of the learner in the VP scenario as a criterion, as this is an important factor in simulation-based environments [43]. The learner is cast for instance in the role of a resident or consultant, being responsible for a patient.

(iv) Encounter-related: We included the setting in which the consultation with the VPs takes place, such as a university hospital or a doctor's office, as a criterion. In doing so, we aimed at avoiding an overrepresentation of well-equipped university hospitals and emergency departments and at providing a realistic variety of facilities. Table 1 provides an overview of all included criteria. Once we agreed on all the criteria and the permitted values for list selection under each criterion, we developed a template that allowed partners to populate the blueprint with VP data.

Table 1. Overview of criteria, permitted values, and sources for comparison.

Criterion	Values	Sources for Comparison
Disease-related		
Key symptoms	N/A	[34–38,44,45]
Final diagnoses	N/A	[46–49]
Disease group	Vascular/Infectious/Neoplastic/Drugs, Toxic/Idiopathic/Congenital/Autoimmune, Immunologic/Traumatic/Endocrine, Metabolic [39]	N/A
Onset	Chronic/Subacute/Acute	N/A
Scenario closure	Long-term treatment/Successfully discharged/Died [26]	N/A
Patient-related		
Age	N/A	[50]
Sex/Gender	Female/Male/Transgender/Intersexual [24]	[51,52]
Sexual orientation	Heterosexual/Homosexual/Bisexual/Not sexually active (child)/Not stated [24]	[53]
Ethnicity	Hispanic/Black/White/Asian/Other [54]	N/A
Profession	Naming of profession/Unemployed/Retired/Student/Child/Not stated	[55,56]
Disability	Yes/No	[57]
Relevant cultural, language, or migration background	Yes/No	[58]
Addiction/substance abuse	Smoker/Ex-Smoker/Alcohol/Illegal drugs/Other/No/Not Stated [25]	[59–61]
Learner-related		
Learner's role	Student/Intern/Resident/Consultant/Other/Not Stated	N/A
Encounter-related		
Setting	Rural Hospital/University Hospital/Hospital/Practice/Outpatient Clinic/Emergency Room [25]	N/A

N/A = Not applicable.

Step 2: Identification of data sources for assessing the representativeness of the blueprint.

All partners agreed on a list of suitable key symptoms that the VPs should present with; these were extracted from the literature [44,45] and available national competency frameworks [34–38].

To identify frequent diagnoses, we based our literature search on a systematic review by Finley et al. that reports on the most common conditions in primary care [46]. Additionally, we included articles that recommend diagnoses to be covered in medical education from a daily-practice perspective [47–49].

To assess whether our populated blueprint is, as intended, a realistic representation of the European patient population, we identified the most recent, pertinent data from the World Health Organization (WHO) and statistics available for Europe to compare to our VPs.

All selected references and data sources are included in Table 1.

Step 3: Populating the blueprint

In this step, we mapped the existing 75 VPs into our blueprint and asked each partner institution to add 25 VPs they intended to develop based on their curricular needs.

Step 4: Refinement and reaching consensus

First, we compared the results of step 3 (i.e., the distributions of suggested patient-, learner-, and encounter-related criteria of the blueprint) to the identified literature and statistics (see step 2). Then, if necessary and feasible, we asked partner institutions to modify their VP scenarios to represent a more realistic patient population.

To foster students' comparing and contrasting of similar cases, which is vital to build competency in clinical reasoning, we excluded key symptoms that were only present in one VP from the final blueprint. Therefore, adjustments had to be made in some cases, leading to a reduced number of key symptoms in the final blueprint.

As the diagnoses of the initially outlined VPs differed substantially from the results of the literature, we applied a Delphi-like approach to reach consensus on the final diagnoses (for details see Appendix A). This approach is widespread in medical education research [62] and curriculum planning [63,64].

Once the final blueprint was approved by all partners, we mapped all VPs to MeSH and the national competency frameworks and performed descriptive analysis for all criteria.

3. Results

Our three main results are the populated blueprint describing the VPs, which has been published as part of the project [65], the descriptive statistics of the criteria, and the actual decision-making process. In the following sections, we show the results of our descriptive analyses.

3.1. Analysis of Disease-Related Criteria

Our final list of VPs includes 29 common key symptoms [65]. The Delphi-like approach resulted in a total of 176 diagnoses across several healthcare disciplines displayed in our blueprint. Of these, 22 are covered by more than one VP [65].

The final diagnoses of our VPs include all 11 main disease categories of the German national catalog of learning objectives in medicine (NKLM) [34], and 15 of 17 disease categories listed in the national framework published by the Polish Ministry of Science [35]. The blueprint also covers 17 of 18 categories in the whitepaper published by the Spanish National Agency for Quality and Accreditation [37], and 11 of 12 categories listed in the French catalog of learning objectives [38]. The Portuguese national framework consists of 5 main groups of diseases that are all covered by our VPs [36]. Although these frameworks vary in their structure and content, they mostly focus on diseases of the cardiovascular, digestive, and respiratory systems. The missing categories were particular topics, such as "safe use of medication" in the French learning objective catalog, or specific disciplines, such as ophthalmology in the Spanish and the Polish frameworks.

Regarding the disease groups of the VINDICATE mnemonic, the most frequent groups were "infectious" (31%), "vascular" (14%) and "immunologic" (14%) (for further values see Appendix B, Table A1).

The VP's onset of symptoms was acute, subacute, or chronic for 62%, 19%, and 19%, respectively. At the end of the scenario, 6% of the VPs die, 36% require long-term treatment, and 59% are successfully discharged.

3.2. Analysis of Patient-Related Criteria

Our blueprint of 200 VPs includes all age groups, from newborns up to 93 years, with an age distribution of 12% between 0–14, 61% between 15 and 64, and 28% above 65. Compared to the general population in Europe in 2021 (15% between 0–14, 64% between 15 and 64, and 21% above 65) [50], our VPs are older, considering that elderly people tend to seek medical care more frequently than the average population.

The final blueprint includes 1% intersexual or transgender patients compared to an estimated rate of up to 2% in European adults [52]. Eight percent of our VPs are described to be homo-or bisexual, which is slightly higher than the population in Europe, in which the lesbian, gay, bisexual, and transgender (LGBT) population varies among countries but is reported highest in Germany with over 7% in 2016 [53].

Regarding ethnicity, our blueprint comprises White (89%), Black (8%), Asian (2%), and Hispanic (2%) VPs. However, we did not find suitable European data sources for comparison.

The professions of the VPs include 27 of the 38 occupational sectors covered in the Eurostat employment statistics [55] with the five most common occupations being teaching professionals, health professionals, researchers & engineers, personal service workers, and sales workers. The most common occupations in the EU are sales workers, office associate professionals, personal service workers, teaching professionals, and drivers & vehicle operators [55]. The proportion of unemployed VPs among the working-age population is 6%, a bit lower than the average seasonally adjusted unemployment rate in the EU, which ranged between 7 and 8% in 2020 and 2021 [56].

In our blueprint, we have 8% of disabled VPs, compared to an estimated prevalence of 6 to 10% for disabilities in Europe [57].

We included 13% of VPs with a relevant cultural or migration background, for example, refugees or VPs with language barriers. In the EU, the proportion of non-EU citizens and people that were born outside of the EU was 5% and 8%, respectively, in 2020 [58].

In the age group over 15 years, 17% of the VPs are smokers, compared to an average of 18% daily smokers in 2019 in the EU [59]. Moreover, 8% of the VPs in this age group have a relevant alcohol consumption which corresponds to the proportion of adults in the EU with daily alcohol consumption [60].

Table 2 provides a summary of patient-related criteria; all criteria are presented in detail in Table A1 (Appendix B).

Table 2. Summary of patient-related criteria and their respective data for comparison.

Criterion	Values	N	% Total	EU/European Data for Comparison	Reference
Age	0–14 years	19	11.5%	15.1%	[50]
	15–64 years	122	61.0%	64.1%	
	≥65 years	55	27.5%	20.8%	
Sex/Gender	Female	101	50.5%	51.7%	[51]
	Male	97	48.5%	48.3%	
	Transgender	1	0.5%	Estimated proportion: 0.1–2%	[52]
	Intersexual	1	0.5%		

Table 2. *Cont.*

Criterion	Values	N	% Total	EU/European Data for Comparison	Reference
Sexual orientation	Heterosexual	115	57.5%	N/A	
	Homosexual	12	6.0%	Proportion of LGBT: 1.5–7.4%	[53]
	Bisexual	4	2.0%		
	Not sexually active (child)	21	10.5%	N/A	
	Not stated	48	23.5%	N/A	
Disability	Yes	14	6.5%	6–10%	[57]
	No	186	93.0%	N/A	
Relevant cultural, language, or migration background	Yes	27	13.5%	5.1% non–EU citizens 8.3% born outside EU	[58]
	No	173	86.5%	N/A	
Addiction/Substance abuse *	Smoker	30	16.6% [2]	18.4% [1] daily smoking	[59]
	Ex–Smoker	11	6.1% [2]	N/A	
	Alcohol	14	7.7% [2]	8.4% [1] daily alcohol	[60]
	Illegal drugs	3	2.4% [2]	"Last month prevalence": 1.2–8.7% [2]	[61]
	Other	1	0.6% [2]	N/A	
	No	111	55.0%	N/A	
	Not Stated	35	17.5%	N/A	

* Numbers do not sum up to 200 (100%) since combinations of values are possible. [1]: Referring to age group ≥15 years. [2]: Referring to age group 15–64 years. N/A = Not applicable.

3.3. Analysis of Encounter- and Learner-Related Criteria

The learner role is in 46% of the scenarios a resident, in 30% a consultant, and in 18% an intern (for more details see Appendix B, Table A1). About one-third (34%) of the encounters occur in a medical practice, 23% in a hospital, 21% in a university hospital, 12% in an outpatient clinic, and 11% in a rural hospital. Of all hospital settings, 31% take place in an emergency department.

4. Discussion

We developed a blueprint for a VP collection that covers a wide range of medical education needs while ensuring a realistic degree of diversity. The approach we followed to develop this blueprint was challenging and time-consuming. Nevertheless, we believe that it was worth the effort as it enabled us to meet our stated objectives.

To reach our first objective of being realistic in terms of patient characteristics at an international level, we compared the VPs described in our blueprint to sources of population statistics, such as WHO or EUROSTAT. We did not rely on randomizing clinical data for the development of the blueprint [66] but rather reached consensus through a cycle of group discussions, a modified Delphi-approach, and verification steps. Overall, our analyses show that the VPs described in the blueprint represent a patient population more diversely and realistically when compared to previous initiatives [24,25,67]. However, despite our best efforts, we still have some deviations we will refine further during the VP development. For example, the VPs cover a wide range of occupations, including unemployed and retired people, but we have an overrepresentation of professions our consortium is familiar with, such as health and teaching professionals. Also, the proportion of disabled VPs and chronic onsets is lower than we intended it to be. On the other hand, about one-third of our VPs require long-term treatment, emphasizing the importance of

chronic conditions in healthcare. We will keep these aspects in mind during the actual development of VPs and refine the collection accordingly.

Our second objective was to ensure the applicability and integrability of the VP collection for medical schools in Europe. To reach this objective, we considered different perspectives from health professions, educators, and researchers across Europe, similar to previous international and interdisciplinary approaches [30,31]. Thus, we were able to consider cultural differences of involved countries [68] as well as country-specific diagnostic and therapeutic approaches [69]. Additionally, we mapped the VPs in our blueprint to national competency frameworks. Through this approach, we hope to ease the integration of the VP collection into the curricula of other schools and increase its acceptance by healthcare educators in Europe [70–72].

Our third objective was to plan a VP collection that is suitable to deliberately practice clinical reasoning by comparing and contrasting similar case presentations. There is no gold-standard available for the optimal composition of a VP collection in terms of key-symptoms, diagnoses, and contextual variation. However, Kassirer et al. pointed out that learning clinical reasoning is fostered by a larger collection of VPs [73]. As we based our approach on available guidance as far as possible [28,74], we believe that covering a range of 29 key-symptoms and 176 final diagnoses is a good starting point, but we also see the need for further expanding the collection in the future. Looking at teaching of clinical reasoning through the lenses of situativity theory [13] emphasizes the importance of the context in making diagnostic and therapeutic decisions. For example, the diversity of the VP characteristics exposed in our blueprint provides a valuable opportunity to provide thoughtful feedback to students on how such factors influence clinical reasoning and can be the source of cognitive errors. A discussion or review of errors is a suitable approach to improve clinical reasoning as long as it includes elaborated feedback [75,76].

In addition to reaching our objectives, our discussions helped us in developing a better understanding of patient- and healthcare-related aspects in other countries, which will enrich our teaching and research. For instance, we had a vivid discussion on defining migration background and differences in countries of origin between our partner countries.

Finally, we believe that our approach emphasizes the importance of creating VP or case collections that are diverse, realistic, as well as applicable and shareable on an international level. We hope that implementing such a VP collection in study programs will contribute to their internationalization, which has the potential to facilitate the mobility of health professionals in Europe.

We are aware that our approach has several limitations.

First, we could not identify data sources based on the patient population in Europe to compare our patient-related criteria. Therefore, we had to use statistical data based on the general population in Europe, which certainly differs in terms of age distribution. In addition, we had to obtain information from various data sources, which may have used different methodologies and underlying definitions. However, our aim was not to simulate a perfect real-world patient population but to consider aspects of diversity and an approximation to a real-world population.

Second, we did not yet perform sub-analyses on the distributions involving the combination of different criteria themselves (for example, how disability status or migration background are distributed in relation to the VPs' sex). During the VP development, further analyses will be undertaken to overcome gender- and ethnicity-related stereotypes.

Furthermore, despite having a diverse group of partners in the project, we must acknowledge that for instance no Scandinavian or Balkan country is represented in our group and therefore, we might be missing the perspective of Northern or Southeastern European countries.

The experience of the recent COVID-19 pandemic taught us that the global health situation can change dramatically in a very short time frame. Global warming, political conflicts, economic crises, but also accelerating technical innovation are likely to contribute to increased fluctuations in patient populations characteristics. Our paper adds to the

existing body of knowledge by proposing a methodology to help educators to efficiently reach a realistic VP or case mix suitable for clinical reasoning training. We foresee that there will be a growing demand for such methods to make the educational system fit the actual needs of the changing society. At the same time, we stress that the authenticity reached by such a methodology is not given for ever and that revisions and updates of VP collections are required to keep them up to date.

5. Conclusions

In this study, we developed a process for designing a blueprint for a VP collection that provides a realistic picture of the European patient population, meets educational requirements, and facilitates deliberate practice of clinical reasoning. We believe that our work can help healthcare educators to assess their own VP or case collections, expand their collections within their schools (or in collaboration with others), or implement a similar process. Despite some limitations, we think that the blueprint, which is the product of this process, is an appropriate starting point for creating the VPs. The dynamic nature of the pandemic situation will probably make it inevitable that we will have to do further adaptations and refinements during the creation phase. Also, we consider the blueprint a dynamic document we will regularly consult and update during and after creating the VPs to preserve the high quality of our VP collection.

Author Contributions: All authors contributed substantially to the conceptualization and data curation. A.M. and L.M. analyzed the data. A.M., L.M. and I.H. drafted the first version of the manuscript. All authors reviewed and edited the draft version of the paper and agreed on the final version. All authors have read and agreed to the published version of the manuscript.

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Appendix A

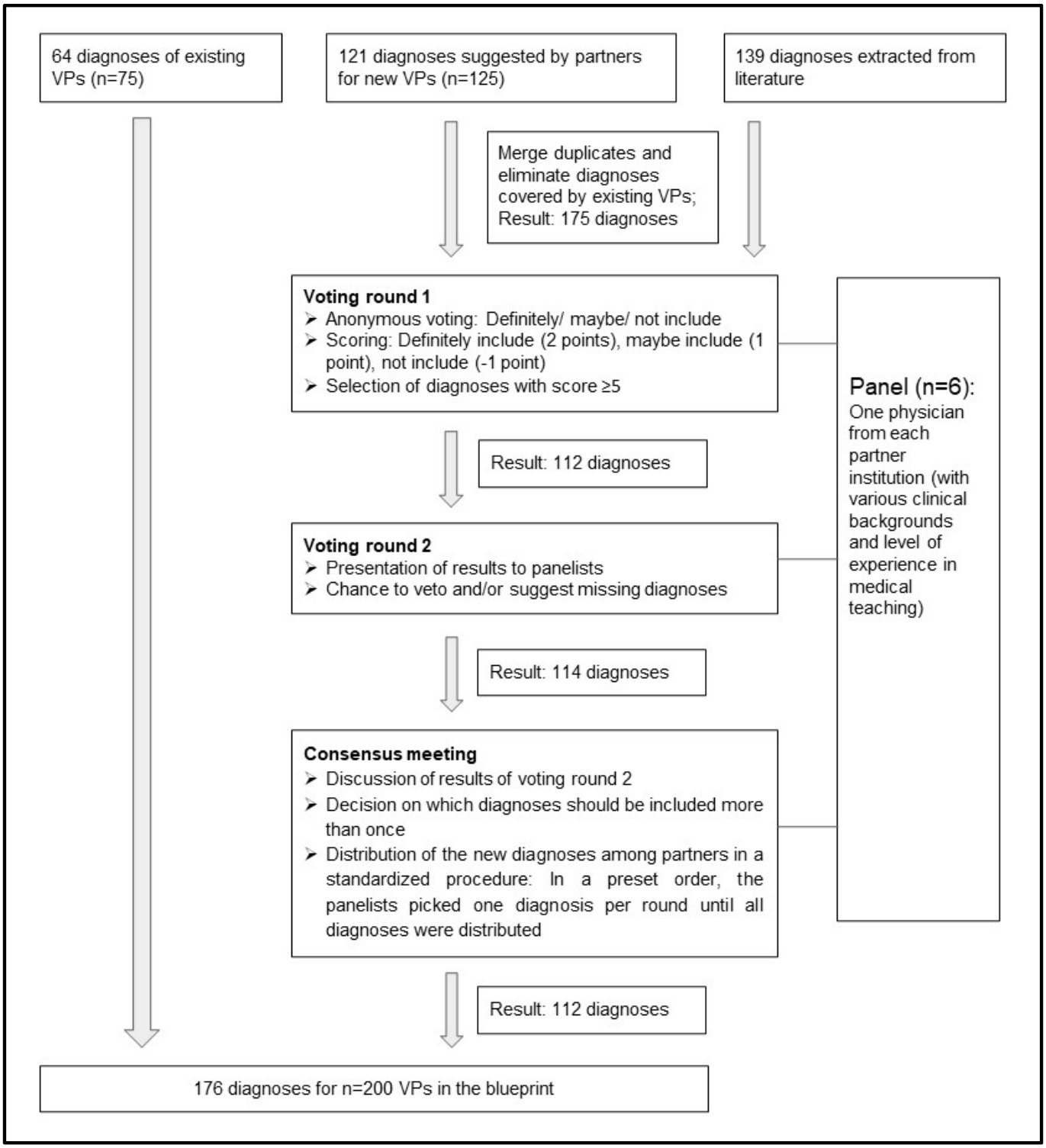

Figure A1. Flowchart of a Delphi-like approach to reach consensus on the final diagnoses to be included in the blueprint.

Appendix B

Table A1. Analysis results of all disease-, patient-, learner- and encounter-related criteria.

Criterion	Values	N	% Total	EU/European Data for Comparison	Reference
Disease-related					
Key symptoms	N/A	see blueprint [65]			[34–38,44,45]
Final diagnosis	N/A	see blueprint [65]			[46–49]
Disease group	Vascular	28	14.0%	N/A	
	Infectious	62	31.0%	N/A	
	Neoplastic	22	11.0%	N/A	
	Drugs/Toxic	9	4.5%	N/A	
	Idiopathic	0	0.0%	N/A	
	Congenital	13	6.5%	N/A	
	Autoimmune, immunologic	27	13.5%	N/A	
	Traumatic	15	7.5%	N/A	
	Endocrine, metabolic	18	9.0%	N/A	
	Other	6	3.0%	N/A	
Onset	Acute	124	62.0%	N/A	
	Subacute	38	19.0%	N/A	
	Acute	38	19.0%	N/A	
Scenario closure	Long-term treatment	72	36.0%	N/A	
	Successfully discharged	117	58.5%	N/A	
	Died	11	5.5%	N/A	
Patient-related					
Age	0–14 years	19	11.5%	15.1%	
	15–64 years	122	61.0%	64.1%	[50]
	≥65 years	55	27.5%	20.8%	
Sex/Gender	Female	101	50.5%	51.7%	[51]
	Male	97	48.5%	48.3%	
	Transgender	1	0.5%	Estimated proportion: 0.1–2%	[52]
	Intersexual	1	0.5%		
Sexual orientation	Heterosexual	115	57.5%	N/A	
	Homosexual	12	6.0%	Proportion of LGBT: 1.5–7.4%	[53]
	Bisexual	4	2.0%		
	Not sexually active (child)	21	10.5%	N/A	
	Not stated	48	23.5%	N/A	
Ethnicity	White	178	89.0%	N/A	
	Black	15	7.5%	N/A	
	Asian	3	1.5%	N/A	
	Hispanic	3	1.5%	N/A	
	Other	1	0.5%	N/A	

Table A1. *Cont.*

Criterion	Values	N	% Total	EU/European Data for Comparison	Reference
Profession	Naming of profession	5 most frequent occupations: teaching professionals, health professionals, researchers & engineers, personal service workers, sales workers		5 most frequent occupations: sales workers, office associate professionals, personal service workers, teaching professionals, and drivers & vehicle operators	[55]
	Unemployed	7	6.3% [1]	6.5–7.6% [1]	[56]
	Retired	56	27.5%	N/A	
	Student	9	4.5%	N/A	
	Child	27	13.5%	N/A	
	Not stated	7	3.5%	N/A	
Disability	Yes	14	6.5%	6–10%	[57]
	No	186	93.0%	N/A	
Relevant cultural, language, or migration background	Yes	27	13.5%	5.1% non-EU citizens 8.3% born outside EU	[58]
	No	173	86.5%	N/A	
Addiction/Substance abuse *	Smoker	30	16.6% [2]	18.4% [2] daily smoking	[59]
	Ex-Smoker	11	6.1% [2]	N/A	
	Alcohol	14	7.7% [2]	8.4% [2] daily alcohol	[60]
	Illegal drugs	3	2.4% [3]	"Last month prevalence": 1.2–8.7% [3]	[61]
	Other	1	0.6% [2]	N/A	
	No	111	55.0%	N/A	
	Not Stated	35	17.5%	N/A	
Learner-related					
Learner's role	Student	3	1.5%	N/A	
	Intern	36	18.0%	N/A	
	Resident	91	45.5%	N/A	
	Consultant	59	29.5%	N/A	
	Other	2	1.0%	N/A	
	Not Stated	9	4.5%	N/A	
Encounter-related					
Setting *	Hospital	46	23.0%	N/A	
	University Hospital	41	20.5%	N/A	
	Rural Hospital	21	10.5%	N/A	
	Practice	68	33.8%	N/A	
	Outpatient Clinic	24	11.9%	N/A	
	Emergency Room	61	30.5%	N/A	

* Numbers do not sum up to 200 (100%) since combinations of values are possible. [1]: Referring to people aged 15–74 years who are actively seeking work. [2]: Referring age group ≥15 years. [3]: Referring age group 15–64 years. N/A = Not applicable.

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Publication 2

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Medical education in times of war: a mixed-methods needs analysis at Ukrainian medical schools

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Abstract

Background As Ukraine struggles with the education of healthcare professionals due to the war, we aimed to identify the specific effects of the war on medical education, the resulting needs, and the expected consequences for schools, faculty, staff, students, and the healthcare system.

Methods In October and November 2022, we performed a survey of students, faculty, and staff of medical schools in Ukraine and conducted semi-structured interviews with faculty leaders (i.e., rectors, vice-rectors). We conducted a descriptive analysis of the survey's closed-ended questions. The survey and the interviews included open-ended questions about war-related restrictions to teaching and learning, resulting needs, and expected consequences, for which we applied a thematic analysis.

Results We received 239 survey responses ($N=49$ faculty and staff, $N=190$ students) and conducted nine interviews with faculty leaders across Ukraine. Most survey participants indicated that they had experienced restrictions or changes to their work or study due to the war (86% of faculty and staff, 69% of students). From the thematic analysis of the survey and interviews, we identified eight themes: disruption of teaching, increased workload, mental stress, financial restrictions, non-war related needs, international cooperation, quality of education, and prospects of future professionals. The quality of healthcare education in Ukraine was threatened, and schools, faculty, staff, and students were under great strain. While already established international cooperation has been supportive, some needs have still not been addressed.

Conclusions We hope that our findings will help researchers and educators from abroad contribute to meeting Ukraine's needs in medical education.

Keywords Ukraine, War, Medical education, Needs, Qualitative research

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Background

Medical education in Ukraine

Medical education in Ukraine has been considered "both one of the highest quality and relative affordability globally" [1]. About 70,000 students (69% female, 31% female) [2, 3] are studying at 36 medical schools [4], consisting of universities and academies located in 19 cities across the country. Also, before the war, Ukraine hosted more than 26,000 international medical students, mostly from India, Africa, and the Middle East [5]. In 2005, Ukraine

entered the Bologna Process which aims to harmonize the various systems of higher education in Europe, by implementing a system of quality assessment, mutual recognition of qualifications, and the introduction of bachelor's and master's study programs [6]. As a result, the standard period of study for a medical degree in Ukraine is 6 years, consisting of a 4-year bachelor's program and a 2-year master's program [7]. However, there are still challenges slowing down the reforms [8, 9]. For example, most medical schools in Ukraine are not part of a university hospital and rely on contracts with nearby hospitals [10], resulting in limited patient contact. However, promising changes have been achieved, such as the implementation of the nationwide Unified State Qualification Exam (USQE) in 2019 [11, 12]. Also, the digitization of medical education was accelerated by the COVID-19 pandemic and is well underway [13].

Current situation in Ukraine

On February 24th, 2022, these developments were stopped when the Russian Federation launched an armed offensive. Since that day, Russia's army has destroyed military facilities, cities, and critical infrastructure across Ukraine [14]. Civilians and soldiers are suffering physical and mental injuries [15, 16] and access to humanitarian aid and healthcare is limited due to a lack of healthcare professionals, insufficient medical supplies, and the destruction of healthcare facilities [16]. Consequently, incidences of war-related conditions, such as injuries, psychological traumata, or infectious diseases are rising, and the management of chronic diseases will probably worsen [17, 18].

Armed conflicts affect the content and quality of medical education [19] and students in Ukraine may delay their studies, or not graduate, or miss out on key learning objectives [1, 16]. For example, students and educators may need to flee from the war or serve at the frontlines [15, 20]. Furthermore, the lack of practical skills that Ukrainian graduates showed before the war, due to remote and hybrid teaching during the COVID-19 pandemic, has aggravated the problem [1, 13].

Needs of medical education in time of war

In their scoping review of maintaining healthcare education during times of war, Dobiesz et al. identified five categories: curriculum, personnel, wellness, resources, and oversight. They described barriers such as threat to safety, decrease in the number of students and teachers, and loss of resources. They suggested targeted interventions such as structural curricular changes and the use of online resources [21].

Duration, localization, and intensity of a war strongly influence the needs and prospects of a country's medical education. Long-lasting wars covering large areas and costing thousands of lives, such as in Afghanistan, Liberia, and Iraq, can severely affect the quality of medical education [22–24]. However, a study of students who had provided medical support in the locally confined one-month Lebanon-Israel war showed that they felt more compassionate towards their patients, were prouder of their profession, and were more experienced in emergency medicine [25].

Students, faculty, staff, and faculty leaders have different perspectives and needs during a war. A study of the mental well-being of medical students during the war in Syria showed that especially low-income students suffered from depression, stress, and anxiety. The authors of that study recommended psychological as well as financial programs to support students [19]. Lafta et al. investigated the long-term effect of personal and professional circumstances of the war on medical students in Iraq, finding that most students were dissatisfied with the quality of education and poor career prospects, and willing to leave the country after graduation. The authors recommended using modern teaching methods, accelerating digitization, and "sustain[ing] the motivation that originally attracted students to study medicine" [26].

Clinical educators are or feel obliged to provide as much medical care as possible while maintaining high-quality teaching for students [27].

In their review of challenges to the education of health professionals during the war in Syria, Bdaiwi et al. argue that education should be seen in the larger context of the healthcare system and organizational and programmatic aspects. They recommended a locally driven education strategy, with increased funding, regulatory structures, and international collaboration [28].

Although the situation and needs of medical students during a war has been explored in various studies, the perspective of faculty members and staff is less evident. Also, the needs of medical education in times of war differ according to the circumstances of the war and are influenced by recent developments in technology and events such as the COVID-19 pandemic. Therefore, the aim of this study is to identify the specific effects of the Russia-Ukraine war on faculty, staff, faculty leaders, and students in Ukraine, the needs that result from it, and the expected consequences.

Methods

To answer this research question, we used a mixed-methods approach. We implemented a survey among faculty, staff, and students to understand their perspectives, and conducted semi-structured interviews with faculty leaders (rectors, vice-rectors, heads of departments), to gain an in-depth understanding of the schools' situation and

needs. For reporting the results of the thematic analysis, we followed the Consolidated Criteria for Reporting Qualitative Studies (COREQ) recommended by Tong et al. [29]. The study was approved by the Institutional Review Board of the Ludwig-Maximilians-University, Munich, Germany (No. 22–0726).

Development of the survey and interview guideline

All authors developed the survey questions jointly, based on a survey assessing the need for teaching clinical reasoning among medical students and faculty [30, 31], following the best practices for item-writing recommended by Artino et al. [32]. The survey encompassed personal data, three single-choice and eight open-ended questions about war-related restrictions to teaching and study, resulting needs, measures taken to handle the situation, and expected impact of the war on teaching, students' future professional life, and the healthcare system. To assess how familiar teachers and students are with forms and methods of remote teaching, we added a multiple-choice question. We created separate versions of the survey for students and faculty, adapting the questions to their perspectives (see Additional file 1: Appendix 1). We implemented them using the LimeSurvey platform, with a tick box on the starting page to give consent for data use. The survey was anonymous and available in English and Ukrainian. We piloted the survey with 12 Ukrainian and German students, faculty, and staff members two weeks before the study to assess the appropriateness of the content and questions. While the survey was well received and did not lack any important aspects, we changed the wording of two questions to enhance understandability.

For the interview guideline, we adapted the open-ended questions of the survey to the perspective of faculty leaders and added a question about international cooperation and policy development (see Additional file 1: Appendix 2).

Data collection

On October 10th, 2022, we sent out an email to medical schools across Ukraine listed in the World Directory of Medical Schools [4] and to the International Federation of Medical Students Association Europe [33]. The email included study information, a link to the online survey, and a request to forward the email to faculty, staff, and students. We sent a reminder after two weeks and closed the survey after six weeks.

At the same time, we identified faculty leaders on the schools' websites and asked them via email to have a semi-structured interview with a psychologist (OY) on the video conferencing platform Zoom. Based on our pilot test we set a time of 30 min. for the interviews. We used a purposive sampling strategy aimed at including interviewees from different parts of the country. Prior to the interview, participants gave their written consent. We conducted interviews until data saturation was reached, i.e., we stopped recruitment when we saw that no more new themes emerged from the data.

Analysis

Personal data and answers to closed-ended questions of the survey were analyzed using descriptive statistics of SPSS software (version 29.0). We translated answers to open-ended questions into English, and coded them using MAXQDA software, applying the coding framework we had previously developed when analyzing the interviews (see below).

The interviews were audio-recorded, transcribed verbatim, anonymized, and translated into English. Two researchers (OY, AM) carried out a thematic analysis of the transcripts following the six steps for qualitative content analysis suggested by Kuckartz [34]. Using an inductive approach, they independently identified codes for a subset of two interviews and reached consensus on a first coding framework. They then coded one interview after another, applying the coding framework and developing it further in an iterative process. They used MAXQDA software (version Analytics Pro 2000) for the coding and discussed discrepancies until consensus was reached. OY, IH, and AM then grouped similar codes into themes. Throughout the process KD, OK, and TS reviewed the coding framework and emerging themes and provided feedback; discrepancies were discussed until consensus was reached.

Results

Participants

Interviews

We conducted nine interviews with faculty leaders ($N=3$ female, $N=6$ male) in nine cities across Ukraine, one of which was in the occupied zone (see Fig. 1).

Survey

We received 239 responses from 49 faculty members and 190 students (see Table 1) working or studying at Ukrainian medical schools. Participants' schools ($N=19$) were located in 13 cities across Ukraine (see Fig. 1 and Additional file 1: Appendix 3), but we did not receive any responses from schools in the occupied zone. The average age was 47 years for faculty and staff (range: 28–70), and 20 years for students (range: 16–45). 71% of participants were female.

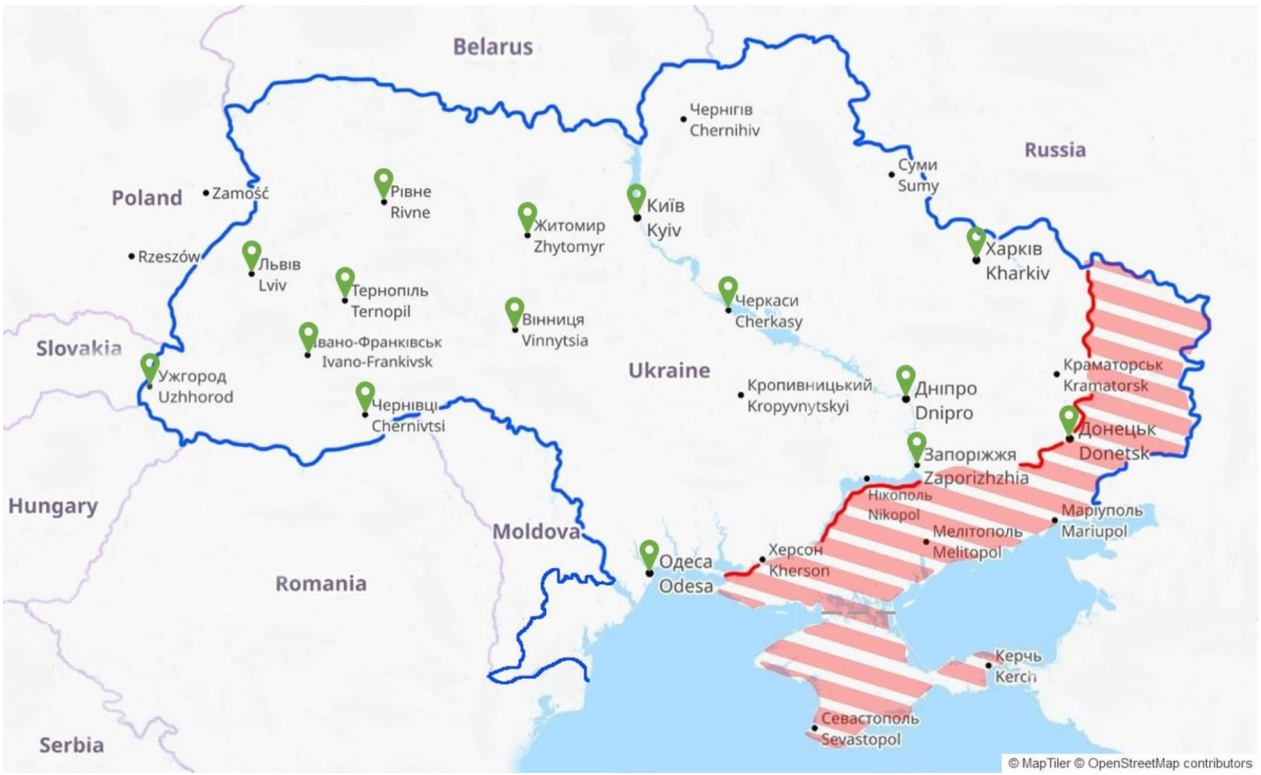

Fig. 1 Geographical location of cities of participants' medical schools. This image was generated using OpenStreetMaps. The occupied zone (marked in red) is shown as it was on October 10th, 2022 [35]. For further details, see Additional file 1: Appendix 3

51% of faculty and staff reported having a Ph.D./doctoral degree. 43% described themselves as being assistant or associate professors, 18% professors and 18% postdocs. Concerning their primary role, 55% indicated being a clinical teacher, 37% teacher of basic sciences, 8% head of department, 6% dean or deputy dean, and 6% administrative staff.

Students from all years of study participated in the survey, with the majority (73%) being in year 1–4 and 23% in year 5 or 6.

Results of single-choice questions related to war and multiple-choice questions on remote teaching

About 35% of faculty and staff and 15% of students reported that their region had been a zone of active fighting since the beginning of the war (Table 2). About 20% of the participants had been forced to flee.

Most participants (86% of the faculty and staff, 69% of the students) reported that their work or study had been restricted or changed because of the war.

When asked for remote teaching formats, most faculty members and students reported experience with lectures (67% and 63%) and workshops (71% and 65%), many also being familiar with learning-management-systems (49% and 34%) and screencasts (51% and 24%).

Thematic analysis of interviews and open-ended survey questions[1]

Most participants agreed that they *"need the war to end as soon as possible" (S78_S)* and *"peace is the main remedy for the situation" (S148_F).* Beyond that, we identified the following eight themes (see Fig. 2):

Disruption of teaching
Increased workload
Mental stress
Financial restrictions
Non-war related needs
International cooperation
Quality of education
Prospects of future professionals

Disruption of teaching

The disruption of teaching had a strong negative impact on medical education in Ukraine, mainly due to (a) students' being prevented from study, (b) loss of facilities,

[1] *Participants' quotations are referenced as: I = interview, S = survey, _F = faculty and staff, _S = student.

Table 1 Description of survey participants

Variable	Description	Faculty (*N* = 49)		Students (*N* = 190)	
		[N]	[%]	[N]	[%]
Age	Mean (range)	47 (28–70)		20 (16–45)	
Sex	Female	35	71%	135	71%
	Male	14	29%	55	29%
Nationality	Ukraine	47	96%	184	97%
	Other	2	4%	3	2%
	Missing	0	0%	3	2%
Educational program mostly related to	Medicine	45	92%	182	96%
	Pediatrics[a]	4	8%	8	4%
Years of working experience	Mean (range)	16 (1–47)		-	-
Primary role(s)	Teacher of clinical department	27	55%	-	-
	Teacher of basic sciences	18	37%	-	-
	Head of department	4	8%	-	-
	(Deputy) dean	3	6%	-	-
	Administration	3	6%	-	-
	Other	1	2%	-	-
Educational level/ Academic title	Ph.D./Doctoral degree	25	51%	-	-
	Postdoc	9	18%	-	-
	Associate/Assistant Professor	21	43%	-	-
	Professor	9	18%	-	-
	Other	6	12%	-	-
Year of study	1	-	-	59	31%
	2	-	-	22	12%
	3	-	-	38	20%
	4	-	-	19	10%
	5	-	-	34	18%
	6	-	-	10	5%
	Intern	-	-	3	2%
	Missing	-	-	5	3%
Educational level applied for	Master[b]	-	-	165	87%
	Bachelor	-	-	8	4%
	Other or missing	-	-	17	9%
Primary role(s)	Budget student (financed by the state)	-	-	149	78%
	Contract student (self-payment)	-	-	38	20%
	Missing	-	-	3	2%

[a] In Ukraine, Pediatrics is a separate study program, [b]Most Ukrainian medical students, who start with the bachelor's program, plan to pursue a master's degree

and frequent air raids resulting in (c) less bedside teaching and practical training, and (d) frequent power and internet blackouts. To maintain teaching, schools (e) implemented remote teaching formats.

Participants reported that at the beginning of the war, many Ukrainian and most international students had gone to western cities or abroad, experiencing some interruption in their studies. For example, one international student at Kharkiv University, who fled when the war broke out, reported: "*The course is online now, but also being offered offline in Western Ukraine (Ivano-Frankivsk), but I think it's still unsafe to travel back to Ukraine, unless there's ceasefire, and peace prevails again" (S141_S).* Some international students even had to quit their studies *"because our home country's national medical board declared that it's not going to recognize our 'online education'" (S138_S).* Although many Ukrainian students returned later, there was still migration from the more affected regions to western or centrally located cities in Ukraine. Schools *"took in [...] students and graduate students" (I10)* but soon reached their capacity. Therefore, *"part of the [Ukrainian] students have simply dropped out,*

Table 2 Questions related to war and remote teaching

Variable	Description	Faculty ($N=49$)		Students ($N=190$)	
		[N]	[%]	[N]	[%]
Region of school has been an active combat zone	Yes	17	35%	29	15%
	No	29	59%	112	59%
	Missing	3	6%	49	26%
Had to flee from home because of the war	Yes	10	20%	39	21%
	No	36	73%	105	55%
	Missing	3	6%	46	24%
Restrictions or changes to work/study due to the war (faculty and staff/students)	Yes	42	86%	131	69%
	No	7	14%	42	22%
	Missing	0	0%	17	9%
Remote teaching formats used/participated in	Lecture	33	67%	119	63%
	Workshop	35	71%	124	65%
	Seminar	22	45%	75	39%
	Case-based learning	24	49%	40	21%
	Problem-based learning	15	31%	7	4%
	Learning-Management-Systems	24	49%	65	34%
	Screencasts /videos	25	51%	45	24%
	Game-based learning	11	22%	27	14%
	Virtual Patients	11	22%	13	7%
	Other	1	2%	3	2%
	None	0	0%	1	1%
	Missing	10	20%	48	25%

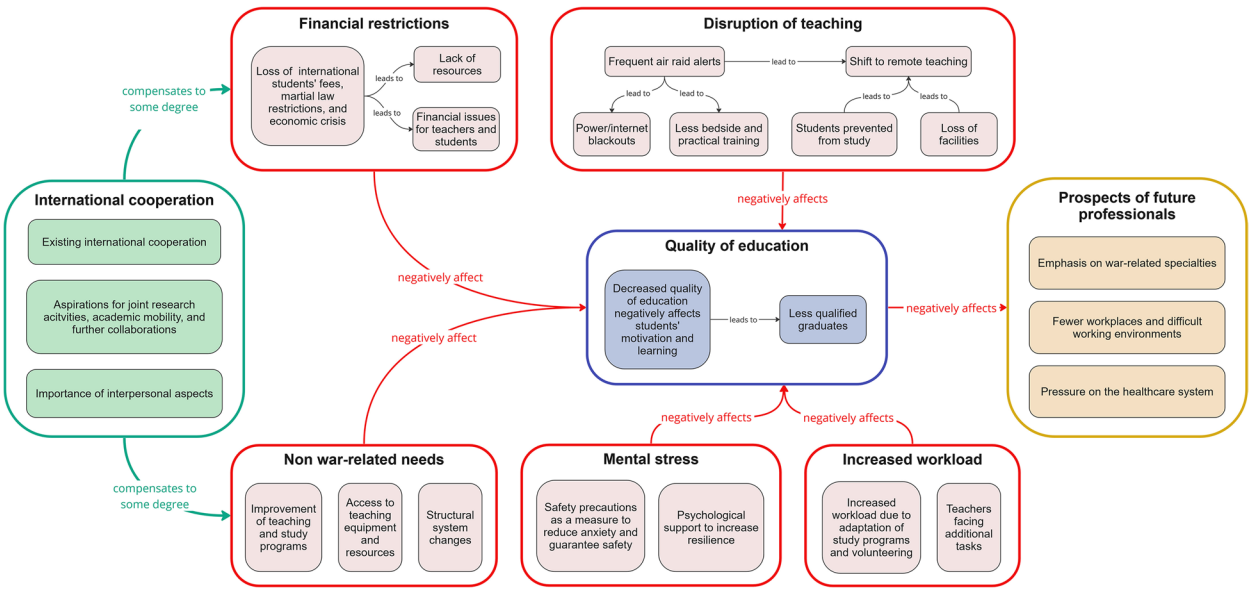

Fig. 2 Graphical representation of themes derived from thematic analysis

a minority has gone abroad, who might […] have found an opportunity to continue studying at other universities" (I3). "Most of those we have lost, however, were international students, because they could not come, or could not afford it any longer, or had other reasons" (I6). Other students experienced difficulties in continuing their studies

because they were serving on the front lines or living in an occupied zone where teaching was continued remotely, often with *"an individual study schedule" (S171_S).*

Relocation of schools to a safe location, or destruction of facilities, led to a disruption of teaching with "*difficult inventory and logistics management circumstances, because we were not given the chance to evacuate the equipment that we had" (I6).*

Participants emphasized that the *"almost daily shelling of Ukrainian cities" (S281_S)* caused a major disruption in teaching, endangered students, faculty, and staff on their way to school, and forced them to stay *"in a shelter (…) during air raid alerts, and as a result, the inability to conduct classes in full" (S194_F).* While students close to the front lines experienced some patient contact and practical training by supporting the care for injured civilians and soldiers, others lacked bedside teaching because many hospitals did not provide sufficient shelters, students were not allowed to enter simulation centers *"due to safety risks" (I5)* or interrupted practical classes could not be continued in the shelters. Facilities for practical training were generally scarce, so "*groups that missed their classes (…) might overlap [with other groups]" (I3).*

Due to missile attacks targeted at infrastructure, power and internet blackouts led to disruption of both online and face-to-face teaching *"as electricity might be unexpectedly switched off or on, and all this affects (…) the learning and communication means" (I9).* As a result, one of the main needs was *"a stable energy system" (I9).*

At the beginning of the war, schools across the country had switched to remote or hybrid teaching for security reasons and to continue teaching. Due to the experience during the COVID-19 pandemic, schools were already *"adjusted to online education" (I10).* Depending on the situation, schools were able to return to face-to-face teaching but *"were forced to switch [back] to remote teaching due to the threat of missile attacks" (S132_F).*

Increased workload

Participants suffered from an increased workload due to (a) adaptation of study programs and (b) volunteering, where (c) teachers faced additional tasks.

Adaptations of study programs not only included earlier starts of semesters, but also *"shortened term of study" (S145_S)* by introducing *"classes on Saturdays" (S86_S)* or *"tightening of curricula" (S146_S).* Also, schools introduced teaching in shifts, depending on *"how many [students] could stay in the facilities depending on the capacities of the shelters" (I1).* These adaptations of the study program led to an increased workload for students, teachers, and *"administration [who] creates individual schedules of classes" (S194_F).*

In case teaching was disrupted by air raid alerts, students and teachers either *"had to put in extra hours, to catch up, to get the work done" (I10)* or students were responsible for filling the gap on their own with more *"independent work and self-study" (S26_F).* Thus, students expressed their need for a *"reduced workload" (S41_S)* and participants expected that *"part of [them] will lose the quality of education, primarily those students who are [not used to] educating themselves" (I9).*

Students and faculty near the frontlines volunteered in *"first-zone medical facilit[ies]" (I7)*, whereas in less affected regions they supported refugees *"with serious health conditions, with chronic illnesses, or acute conditions" (I10).* Also, teachers trained soldiers and citizens *"to provide first aid [or] taught them how to stop bleeding" (I3)* in simulation centers. One school even launched *"a psychological rehabilitation center where we offer advice to [relocated] patients [and]a call center assisting everyone in need" (I8).*

Overall, the loss of teachers who migrated, volunteered at the frontlines, or were dismissed due to budget restrictions, led to an *"increased workload for those who remained" (S132_F).* Also, from the beginning of the war, many teachers had been *"active in additional international projects, which increase[d] the workload and the risk of professional burnout" (I5).* Therefore, *"better working conditions to prevent the outflow of qualified teachers" (S132_F)* were needed.

Mental stress

This theme includes (a) anxiety, (b) safety precautions, (c) psychological support, and (d) resilience.

Faculty and students suffered from mental stress and anxiety with a negative effect on students' learning: *"In the days when air raids are long, and the phone has an endless stream of messages about missile strikes on the cities of your country, it is extremely difficult to study, the emotions that you experience are tiring" (S21_S).* Even in the absence of air raid alerts, students reported that *"it became harder to perceive information and focus on the learning process" (S19_S),* leading to *"poor academic performance" (S207_S).* Teachers expected that the *"excessive levels of stress and anxiety negatively affect the psychological state [of students], which in the future will lead to an increase in psychological and mental disorders among graduates" (S233_F).*

Safety precautions to reduce anxiety and guarantee safety of faculty, staff, and students in case of air raids included making evacuation plans and providing shelters nearby. However, possibilities were limited, and at some schools there still was need for improvement in the amount, quality, and proximity of shelters.

To foster resilience and prevent negative consequences of mental stress and anxiety, schools offered *"psychological support for both our teachers and our students" (I5).* Despite the difficult circumstances, interviewees thought that the Ukrainians *"adapted for the reality that we are currently in" (I8)* or even *"that it will make us stronger" (I9).*

Financial restrictions

There were financial restrictions due to (a) the loss of international students and (b) martial law restrictions leading to (c) lack of resources and (d) financial issues for teachers and students. The situation was worsened by (e) the economic crisis due to the war.

The *"decrease in the number of foreign students" (S135_F)* resulted in a loss of tuition fees for schools. To counteract this, participants suggested *"a special transit visa [allowing them] to fly through a country of the European Union and reach the border of Ukraine" (I9).*

"Due to the martial law restrictions" which allowed schools to spend their money only on the bare necessities, schools were limited in buying teaching equipment, such as *"books, (…) literature, and (…) mannequins" (I3)*. Budgetary constraints also resulted in postponing repair of buildings and *"reducing salaries" (S26_F*) for teachers, who asked for *"support from the state" (S51_F)*.

The economic crisis worsened the situation of teachers and "*parents that pay tuition fees" (F148_F)* as *"inflation effectively reduced wages by half" (I4)*.

Non war-related needs

General needs mentioned by participants were (a) improvement of teaching and study programs, (b) access to teaching equipment and resources, and (c) structural system changes.

Aside from the war, students and faculty wished for *"a completely different approach to teaching" (S175_S)* and suggested *"re-training of teaching staff" (S200_F).* They suggested improving study programs by integrating foreign languages, *"updat[ing] the curriculum" (S63_S),* and *"increas[ing] the time of practical classes and visits to patients" (S277_S).* Accordingly, participants stressed that additional university hospitals are a *"prerequisite for quality training of doctors" (S247_F).*

There was a need for more or better teaching equipment, such as *"equipment for simulation centers" (S247_F)* or *"modern laboratories" (S25_F*) and a need for technical infrastructure and devices such as "*large databases of (…) teaching materials" (S265_S)* and *"simulation training [and] virtual patients" (S16_F).*

Faculty and students wanted changes in processes and structures within their schools including *"less bureaucracy in state institutions" (S211_S), "eradication of corruption" (S3_S), "valuing students as equal participants in the educational process [and] abandoning the Soviet hierarchical model in education" (S15_F).*

International cooperation

This theme covers (a) existing international collaborations, (b) aspirations for joint research activities, academic mobility, and further collaborations, and (c) the importance of interpersonal aspects in international cooperation.

Faculty leaders hope that international collaborations, which had been established after the beginning of the war and led to the provision of generators or train-the-trainer courses, will continue in the future. Also, they expressed their need for further support, *"for the purchase of medical equipment, training equipment like mannequins, or funding for the renovation of certain buildings" (I6).*

Joint research activities with international partners were regarded as helpful *"to maintain our research potential. So that the researchers (…) would not leave the country (…), but rather be up to date with the leaders of their scientific field" (I10).* Participants saw the *"academic mobility of students and teachers" (S233_F)* as *"a great experience" (I1)* that enables students to learn in a peaceful atmosphere and teachers *"to see the best practices and, having returned home, to implement new teaching methods" (I1).* However, there were also concerns that the "*most experienced" (I7)* teachers might stay abroad. Also, participants envisioned more international collaborations for *"creating simulation centers" (I1)*, implementing *"Dual Master's Degree Programs" (I5)* or having "*guest lectures, even if they were offered online" (I6).*

Participants emphasized the importance of interpersonal aspects of such international cooperation: *"Of course, it is important that we feel that we are not alone (…) when you experience something first-hand—the shelling and what that entails, the soldiers being killed, our population and our kids being killed—that constant stress, constant anxiety -. And to continue working under those conditions—no European, no other person [outside the situation] can understand that. Therefore, maintaining those contacts has significance in terms of practice and research, but also in terms of maintaining cultural ties, maintaining interpersonal, individual ties (…) one individual can have a major impact." (I10).*

Quality of education

A deterioration of the quality of education negatively affects (a) motivation and (b) learning, leading to (c) less qualified graduates.

Participants described a change in student motivation in two directions: Students wanted *"more practice, working directly in the hospital, with patients" (S73_S)* as they are motivated to support their country. However, *"due to teaching being mostly remote and not always synchronous, [students'] motivation still gradually spirals down" (I6).* Therefore, teachers often had to *"give motivational talks to support students" (S132_F).*

While some participants believed that the quality of education *"has not deteriorated" (I8),* others were concerned that *"the consequences [of remote teaching] [would] be negative in terms of obtaining and assimilating knowledge" (S187_S).* Also, they anticipated that the limited access to patients and simulation centers would *"impair [students'] communication skills" (S247_F)* and exacerbate their lack of practical skills that already existed due to the COVID-19 pandemic: *"These periods will, no doubt, find their reflection on the quality of those students' training, especially (…) the students who were in their fifth and sixth years of study." (I4).* To support students, *"the procedure for conducting tests" (S229_F)* was simplified, which potentially leads to *"a decrease in the qualification of doctors, because they took away the minimum passing score and changed the form of testing" (S134_S).* While some students expected that the lack of practical training could *"be corrected by our own efforts now or during the internship" (S73_S)* or *"do not see any critical problems" (S133_S)* for their professional life, others were concerned that *"it will be more difficult to "acclimatize" during the internship" (S190_S)* or even to find one *"because after online training they do not want to hire me" (S285_S).*

Prospects of future professionals

This theme covers expected effects on students' professional lives in the future with (a) emphasis on war-related specialties, (b) fewer workplaces and difficult working environments for future professionals, and (c) pressure on the healthcare system.

Participants observed an emphasis on war-related specialties such as *"plastic surgery and prosthetic medicine" (S211_S) or "military surgeons"* (S64_S). Some stressed the *"uniqueness of our experience"* (I5) which could be shared with other countries in the future. Also, they expected an *"increase in the number of patients requiring long-term physical and psychological rehabilitation" (S233_F),* leading to a shift towards these specialties.

Participants expected a *"reduction of workplaces"* (S64_S) and a difficult working environment for future professionals since *"many health care facilities are destroyed" (S73_S). "The need for doctors will increase" (S13_S)* due to the war but at the same time there is an expected decrease in the number of physicians due to migration, burnout, or death on the frontlines, resulting in an *"increase in the amount of work" (S222_S)* in the future. Students feared that they might have to *"work in cities where large-scale hostilities are taking place, and (…) make a lot of efforts to rebuild hospitals and restoring the normal state" (S78_S)* or that *"it will be necessary to go to the front" (S111_S).*

There was *"a very powerful load on the health care system" (S4_S)* due to the loss of facilities, material, and healthcare professionals resulting in a *"deterioration in the quality of care" (S17_F).* Funding programs that were initiated years ago to improve *"the healthcare system of Ukraine will [now] have to be invested in the restoration of the system"* (S262_S). Despite these negative effects, participants remained hopeful: *"This cohesion and purposefulness demonstrated not only by doctors but also by the authorities (…) gives us hope that in the post-war period, all this will remain" (I7)* and that *"the war [will] be an impetus to improve medicine in Ukraine" (S93_S).*

Discussion

Our study shows that the quality of medical education in Ukraine is threatened by several war-related factors, mainly the disruption of teaching, financial restrictions, increased workload, and mental stress, all of which have a negative impact on students' learning. Non-war-related general needs such as modern equipment or more practical training in the study programs exacerbate these challenges.

Our findings are largely consistent with those of the scoping review by Dobiesz et al. [21] on barriers and targeted interventions to sustain healthcare education during wartime. We found similar topics, such as threat to safety, loss of resources, structural changes in curricula, and use of online resources. However, due to the broader scope of our study, which included the perspective of faculty and staff, we put our findings into other themes. For example, as in Dobiesz et al., our participants reported a loss of students. This then led to a budgetary loss for schools which we categorized as "financial restrictions", which is different from Dobiesz et al. who categorized the loss of students as an issue of "personnel".

Beyond that, we identified the theme of prospects of future professionals with an anticipated increase in workload and worse working conditions. This is in line with recent publications about the situation of medical students inside and outside Ukraine [16, 36]; the students not only suffer from the current circumstances but also face an uncertain future. However, in contrast to recent studies

in Iraq [22, 26] we did not identify a tendency among students to plan to leave the country. This might be because we collected data eight months after the war began, so the situation was still new and students might still have been hopeful that the war would end soon, whereas students in Iraq had already experienced years of armed conflict.

Participants described remote teaching as a proven measure used when teaching was disrupted, but consistent with recent literature the availability of internet, appropriate equipment, or access to platforms remained challenges [37–39].

In general, despite our efforts, we received very few responses from schools in the occupied zone. Thus, the measures described by the participants to continue and sustain teaching are probably mostly applicable to less affected regions, and we must assume that maintaining medical education in the occupied zone is even more challenging. Since the medical schools in the western cities have taken in many students who have migrated from the more affected regions, the situation is tense, with an unstable balance of students that is subject to constant change.

A major strength of this study is the triangulation of investigators, of methods (i.e., interviews and surveys), and of data sources (i.e., faculty leaders, faculty, staff, and students), that enabled us to "gain multiple perspectives and validation of data" [40].

While the data of most studies in the field of medical education during war have been collected retrospectively or after several years of ongoing conflict [24, 19], we identified restrictions, needs, and expectations during the first year of the war. To combine these approaches, we recommend conducting a longitudinal study across healthcare professions to examine how restrictions, needs, expectations, and perspectives change during and after a war. The themes we identify can serve as a valuable framework for implementing such a study, which could also investigate whether anticipated consequences were realized.

We are aware that our study has several limitations. First, we focused our sampling strategy on key stakeholders in medical education and did not specifically target other healthcare professions. Involving all healthcare professions might broaden the perspectives and new themes might even evolve. Second, as the situation in Ukraine has been constantly changing, our findings might be influenced by events at the time of data collection. For example, on the day we sent out the survey invitations, Russia started attacking the energy infrastructure across Ukraine [35] and consequently we identified stable electricity as an important need. Third, due to the translation of the interviews and survey responses into English, the meaning of participants' statements may not have been fully reflected. However, we tried to minimize this effect, by employing an experienced Ukrainian researcher, double checking the translations, and discussing uncertainties in the team.

Conclusions

In summary, we conclude that the majority of medical schools across Ukraine, including faculty, staff, and students, are facing various challenges to maintain medical education during the war. Although international partners and programs have supported schools in different ways, they could not compensate for all needs and the sustainability of the students' education is still threatened. Therefore, our findings hopefully will allow future programs and collaborations to be better adapted to Ukraine's specific needs, especially, by addressing the lack of bedside teaching and practical training. Regardless of the current war, participants have expressed the need to continue the reform process of medical education in Ukraine, which could be supported by international cooperation in several ways. For example, consultations with international partners could support the establishment of university hospitals or initiate new models of cooperation between medical schools and hospitals.

Also, researchers and educators outside of Ukraine can contribute by initiating joint research projects or providing train-the-trainer courses to support the advancement of medical education towards more case-based and learner-centered teaching approaches. In comparison to traditional teaching methods, these have been proven to be more effective in acquiring factual and practical knowledge and in supporting medical students in self-regulated learning [41–43]. A recent study from Japan showed that a learner-centered approach even stimulated self-regulated learning in students who were strongly accustomed to teacher-centered methods [44]. Especially in times when teaching is disrupted or there are not enough teachers available, self-regulated learning can be a helpful tool for students that contributes to maintain education. Medical schools in Ukraine welcome additional and flexible mobility programs with international partner schools, so that their students can fill teaching gaps, such as bedside teaching, to maintain the quality of education. Mobility programs can also help those medical schools that have been severely impacted by disruption of teaching or that have accepted many students from the more affected regions, by temporarily reducing the number of students.

These and other collaborations could be established through the European funding schema, such as international staff and student mobility programs, Erasmus+higher education cooperation partnerships, or capacity building grants [45].

Supplementary Information

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Additional file 1.

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Authors' contributions
All authors contributed substantially to the conceptualization. OK, TS, and KD supported in distributing the survey and recruiting interviewees. OY conducted the interviews. AM performed descriptive analysis. AM and OY developed the coding framework. AM, OY, and IH derived themes from the coding framework. OK, TS, and KD reviewed the coding framework and themes. AM prepared Fig. 2 and drafted the first version of the manuscript, under supervision of IH. All authors reviewed and edited the draft version of the paper and agreed on the final version. All authors have read and agreed to the published version of the manuscript.

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Availability of data and materials
The datasets generated during and/or analyzed during the current study are not publicly available due to their qualitative nature but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was carried out in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the Ludwig-Maximilians-University, Munich, Germany (No. 22–0726). All interviewees signed an informed consent prior to the interview. Survey participants gave their consent by ticking a box on the starting page of the survey before participation.

Consent for publication
Not applicable.

Competing interests
The study is part of the thesis of AM. The authors declare that they have no competing interests.

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Publisher's Note

Additional file 1: Appendix 1

Survey for faculty and staff			
Question		**Answer options**	**# Responses (%)**
Please indicate your age:		Number	49 (100%)
Please indicate your sex:		Female, Male, Other	49 (100%)
What is your country of origin?		Ukraine, Other	49 (100%)
In which school and city do you work?		Free text	45 (92%)
What educational program do you relate mostly to?		Medicine, Pediatrics, Other	49 (100%)
What is your highest educational level and/or academic title?		Junior Specialist, Specialist, Bachelor, Master, Ph.D./Doctoral degree, Postdoc, Associate/Assistant Professor, Professor, None, Other	49 (100%)
How would you describe your primary role/roles at your school?		Teacher of basic sciences, Teacher of clinical department, Administration of educational institution, Head of department, Dean, Deputy dean, Researcher, Other	49 (100%)
How many years of work experience in healthcare education (excluding years of undergraduate study) do you have?		Number	49 (100%)
Has the region where you work been an active combat zone so far?		Yes / No	46 (94%)
Did you have to flee from home because of the war?		Yes / No	46 (94%)
If yes:	When and where did you go? Where are you living at the moment?	Free text	9 (18%)
Are there any restrictions or changes to teaching at your school due to the war?		Yes / No	49 (100%)
If yes:			
	Please describe any restrictions or changes that come to your mind.	Free text	37 (76%)
	What measures have been taken so far to handle the situation?	Free text	36 (73%)

	Please describe the needs to improve your current teaching situation and/or for the teaching at your school in general?	Free text	32 (65%)
What future implications (due to the war) do you expect for teaching at your school?		Free text	39 (80%)
What future implications (due to the war) do you expect for the students?		Free text	39 (80%)
What future implications (due to the war) do you expect for the healthcare system?		Free text	38 (78%)
In your opinion, what are the most important needs of healthcare schools in Ukraine?		1., 2., 3., other	37 (76%)
Is there anything else (not war-related) that should be improved regarding the teaching at your school?		Free text	30 (61%)
Do you want to add a comment (e.g., about something not mentioned in the survey that you consider important, or something you heard of other healthcare schools?		Free text	8 (16%)
Which of these teaching methods and forms have you applied online so far?		Lectures, Seminars, Workshops, Case-based learning, Problem-based learning, Learning- Management-Systems (e.g., Moodle), Game-based learning (e.g., Kahoot!), Screencasts /videos, None, Other	39 (80%)

Survey for students		
Question	**Answer options**	**# Responses (%)**
Please indicate your age:	Number	177 (93%)
Please indicate your sex:	Female, Male, Other	190 (100%)
What is your country of origin?	Ukraine, Other	187 (98%)

In which school and city do you study?		Free text	172 (91%)
What educational program do you relate mostly to?		Medicine, Pediatrics, Other	190 (100%)
Your year of study:		1, 2, 3, 4, 5, 6, intern, doctoral/PhD studies, Other	185 (97%)
What educational level are you applying for?		Junior Specialist, Specialist, Bachelor, Master, Ph.D./ Doctoral degree, Other	190 (100%)
How would you describe your primary role/roles at your school?		Budget student (financed by the state), Contract student (self-payment), Exchange student, Part-time student, Tutor, Group leader, Other	190 (100%)
Has the region where you study been an active combat zone so far?		Yes / No	141 (74%)
Did you have to flee from home because of the war?		Yes / No	144 (76%)
If yes:	When and where did you go? Where are you living now?	Free text	31 (16%)
Are there any restrictions or changes to your study at your school due to the war?		Yes / No	173 (91%)
If yes:			
	Please describe any restrictions or changes that come to your mind.	Free text	101 (53%)
	What measures have been taken so far to handle the situation?	Free text	78 (41%)
	Please describe the needs to improve <u>your</u> current study situation and/or the study at your school <u>in general</u>?	Free text	76 (40%)
What future implications (due to the war) do you expect for your study?		Free text	117 (62%)
What future implications (due to the war) do you expect for your future professional activities?		Free text	112 (59%)
What future implications (due to the war) do you expect for the healthcare system?		Free text	112 (59%)

In your opinion, what are the most important needs of healthcare schools in Ukraine?	1., 2., 3., other	113 (59%)
Is there anything else (not war-related) that should be improved regarding the study at your school?	Free text	74 (39%)
Do you want to add a comment (e.g., about something not mentioned in the survey that you consider important, or something you heard of other healthcare schools?	Free text	19 (10%)
In which of these teaching methods and forms have you participated online so far (during your study)?	Lectures, Seminars, Workshops, Case-based learning, Problem-based learning, Learning- Management-Systems (e.g., Moodle), Game-based learning (e.g., Kahoot!), Screencasts /videos, None, Other	142 (75%)

Additional file 1: Appendix 2

Guideline for semi-structured interviews
Has the region where you work been an active combat zone?
Are there any restrictions or changes to teaching at your school due to the war? Please describe any restrictions or changes that come to your mind.
What measures have been taken so far to handle the situation?
What do you think are the most important needs of your school?
What future implications (due to the war) do you expect for teaching at your school?
What future implications (due to the war) do you expect for the students?
What future implications (due to the war) do you expect for the healthcare system?
What wishes or suggestions do you have for future cooperation and policy development, nationally and internationally?

Additional file 1: Appendix 3

Table 1: Overview of participants' schools and cities

School	City	# Interviews	# Faculty and staff	# Students
Cherkasy National University named after B. Khmelnytsky	Cherkasy	0	1	8
Bukovinian State Medical University	Chernivtsi	1	11	41
Dnipro State Medical University	Dnipro	1	3	8
Donetsk National Medical University	Donetsk	1	0	0
Ivano-Frankivsk National Medical University	Ivano-Frankivsk	0	0	2
Kharkiv National Medical University	Kharkiv	1	3	2
V. N. Karazin Kharkiv National University	Kharkiv	0	0	1
Bogomolets National Medical University	Kyiv	1	0	4
Taras Shevchenko National University of Kyiv	Kyiv	0	11	18
Shupyk National Healthcare University of Ukraine	Kyiv	0	5	1
-not explicitly stated-	Kyiv	0	0	5
Danylo Halytsky Lviv National Medical University	Lviv	1	1	3
Odessa National Medical University	Odessa	1	0	0
Luhansk State Medical University	Rivne	0	1	0
I. Ya. Horbachevsky Ternopil National Medical University	Ternopil	1	2	0
Uzhhorod National University	Uzhhorod	0	1	0
Pirogov National Medical University, Vinnytsia	Vinnytsia	0	4	73
Lesya Ukrainka Volyn National University of Vinnytsia	Vinnytsia	0	1	0
Zaporizhzhia State Medical University	Zaporizhzhia	0	0	1
Zhytomyr Medical Institute	Zhytomyr	1	1	5
Missing	-	0	4	18
Total		**9**	**49**	**190**

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