Important aspects of the experience of isolated work of a multidisciplinary medical institution in Ukraine in the context of a sudden outbreak of hostilities

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Irpin Central City Hospital, a municipal non-profit enterprise, provides routine and emergency medical care to residents of the cities of Irpin, Bucha, Gostomel and surrounding villages, as well as emergency medical care to people affected by road accidents and man-made accidents/disasters. The total population served by the hospital is almost 120,000.

The hospital will have 347 beds, which are divided into surgical and therapeutic departments, an intensive care unit with 6 beds and a laboratory and diagnostic unit (general clinical laboratory, functional diagnostics, ultrasound and computed tomography), an infectious disease and admission departments.

The hospital is staffed with surgical (general surgeons, traumatologists, anaesthetists, gynaecologists, urologists, endoscopists) and therapeutic (general practitioners, cardiologists, functional diagnosticians, etc.) specialists.

The surgical unit consists of 3 operating rooms equipped with modern endoscopic complexes, where it is possible to perform surgical interventions of II–III level of complexity.

The hospital also has 5 operating rooms for gynaecological interventions and minor surgery.

The water supply, power supply and heating systems are centralised. In the event of an emergency power outage, all departments are connected to an additional source of centralised power supply (backup input to the hospital's power distribution board), and a separate autonomous diesel generator provides power to 3 operating theatres and the intensive care unit (fuel reserve for 12 hours of continuous operation).

At the time of the outbreak of hostilities, the total planned stock of medicines and consumables allowed the hospital to cover the average weekly surgical activity (up to 100 surgeries) with 10–20 doses of red blood cells and 100–130 doses of fresh frozen blood plasma.

In general, in terms of structure, scope of medical services provided and the number of people served, the hospital's work is comparable to that of district hospitals in Poland or Germany.

In the first hours after the outbreak of hostilities, the hospital administration was dealing with the following issues related to the organisation of medical care for the wounded and the life support of the institution:

- Ensuring a sufficient number of beds to receive the wounded;
- Forming medical teams and determining the procedure for providing medical care in extreme conditions;
- Arranging additional operating theatres and triage rooms, protecting medical staff and patients from firearms (bullets, mine fragments, shells), injuries from building debris, etc.;
- Providing an additional supply of medicines and consumables;
- Providing donor blood products;
- Providing a reserve of food, drinking and industrial water, and setting up a food supply system in extreme conditions;
- Additional provision of the hospital with autonomous power sources with fuel reserves;
- Accommodation for healthcare workers and their families;
- Measures to respond to the possible disruption of the sewage system and centralised waste disposal (as a result of hostilities).

A responsible person from the hospital administration and heads of specialised departments was appointed for each event.

The issue of a sufficient number of beds to receive the wounded was resolved by discharging patients who were in hospital as soon as possible, but whose hospital stay was nearing completion in accordance with clinical protocols or whose course of illness was not complicated. Within 1 hour,
these patients were issued medical documents and provided with appropriate recommendations, and primary care physicians (family doctors) were notified through the medical information system and a chatbot in the messenger. This freed up 94% of the beds for the wounded.

To ensure the provision of medical care, the hospital's medical staff was switched to a 24/7 operation mode immediately after the start of hostilities. The hospital's medical director, together with the heads of the departments, formed emergency teams of various types, which were focused on the potential mass delivery of victims.

The first team was tasked with medical triage in the emergency department. This team was led by the most experienced surgical specialist.

The medical triage was guided by the Simple Triage And Rapid Treatment (START) system, the principles of which are to divide the victims into 4 groups depending on their condition and the urgency of medical care [1, 2].

Priority group I, or "red group". Victims in critical condition with severe injuries that required emergency care.

Priority Group II, or "yellow group". Victims with serious injuries that do not pose a direct threat to life.

Priority Group III, or "green group". Victims with minor injuries and disorders, who can be provided with medical care as a last resort.

Priority group IV, or the "black group". Victims with life-threatening injuries in need of palliative care.

For each of the above groups, appropriate zones were allocated, and experienced surgeons and an anaesthetist–resuscitator directly supervised medical triage.

The second team, designated as a surgical team, consisting of two surgical doctors and an anaesthetist, was directly involved in the patient who needed surgery.

If clinically necessary, the surgical team was joined by traumatologists, neurosurgeons or urologists who provided certain stages of surgical care.

The third team, which provided medical monitoring of patients after surgery, included therapeutic doctors and interns.

It should be noted that the brigades also included medical workers who were not employed by the hospital but lived nearby and were unable to reach their medical facilities located in Kyiv or other settlements of the Kyiv region on the day the hostilities began.

These medical workers, including a neurosurgeon, trauma surgeon, interns, nurses, and junior medical staff, were added to the hospital's staff by administrative order and included in the payroll.

Similar teams were formed among nursing and junior medical staff and the housekeeping service.

The teams were formed on the basis of an 8–hour work shift, which allowed for appropriate rotation and rest time.

The additional operating rooms were deployed by adding anaesthetic and respiratory equipment and general surgical instruments (from the hospital's reserve) to 5 operating rooms used for gynaecological and minor surgery.

On the ground floor, using doctors' offices and common areas, we additionally created examination and sorting rooms and anti–shock wards.

The examination and triage wards had conditions for primary surgical treatment of wounds and dressings or small–scale medical procedures, anti–shock measures (central vein catheterisation, massive infusion, cardiopulmonary resuscitation, pain relief, etc.)

On the ground floor, the windows were protected from shell and bullet fragments as much as possible with sandbags, while on the other floors they were covered with wooden shields and old mattresses. Particular attention was paid to the operating and intensive care rooms, as well as to the wards where patients who were unable to move on their own were kept. The beds were placed in the area protected by the walls as much as possible and in rooms with windows facing the hospital courtyard.

The delivery of a significant number of victims and their appropriate treatment necessitated the creation of a reserve of medicines and consumables. In a short time, a decision was made to replenish the stock of medicines and consumables with medicines and consumables from pharmacies located near the hospital. In the presence of a pharmacy employee, a representative of the hospital and local authorities, the necessary medicines were transferred to the hospital under the relevant act.

Similarly, food and drinking water supplies were replenished from neighbouring shops, and the relevant goods were handed over to the hospital representatives under the relevant acts.

During the first 3 days, the Transfusion Department received more than 100 voluntary donors, and the blood received from them was used to produce red blood cells and fresh frozen plasma.

Understanding that the amount of available donor blood and its components is limited, a decision was made to allow conditionally compatible haemotransfusion (see table), and in extreme situations to allow haemotransfusion of non–quarantined donor blood and its components.

In view of the possible exhaustion of all donor blood stocks, a decision was made to directly transfuse donor blood from healthcare workers who have undergone a routine preventive examination that includes testing for blood–borne infections or from donors tested using rapid tests.

The hospital administration was faced with the issue of food for patients and medical staff. In peacetime, the hospital's food supply was outsourced, and with the outbreak of hostilities, the supply of food packages was stopped. The hospital did not have a full–fledged food unit, so the food packages were unpacked, stored and distributed to the wards in the available premises. Within 2 hours, representatives of the hospital administration and the economic service received grills, utensils for cooking a large amount of food and mobile...
kitchens, as well as a significant amount of firewood from a municipal enterprise engaged in landscaping and holding mass public events. A catering team was formed from middle and junior medical staff and volunteers. The team leader was tasked with optimising the range of dishes (optimising the number of dishes in accordance with the meal plans) and reducing consumption rates in order to save food as much as possible. For ethical and medical reasons, as well as taking into account the psychophysical burden on surgical doctors, the dietary changes did not apply to patients, surgeons, traumatologists, anaesthetists, children and the elderly.

The issue of technical and drinking water supplies was resolved with the involvement of the local unit of the State Emergency Service (analogous to rescue services). Two tanker trucks with drinking water (27 cubic metres) and two tanker trucks with industrial water (30 cubic metres) were sent to the hospital. All water tanks, including hygienic baths, were also filled.

Realising that the capacity of the existing autonomous power supply source (diesel generator) may not be sufficient to ensure the operation of the facility, the local authorities provided an additional diesel generator (280 kW, 312 hours of continuous operation) and a fuel reserve (4.5 tonnes), which allowed for double autonomous power supply backup and, if necessary, to provide energy to additional premises.

Given that the medical staff had to work 24/7, rooms were allocated for rest, off–shift, and eating. In addition, 20% of medical staff were in the hospital with family members (children, spouses or parents). The stay of family members of healthcare workers in the hospital was due to a number of factors: there was no one to leave minor children or elderly parents with, fear for their families who could not evacuate, and it was too risky to leave them in their own homes. Separate rooms (wards) were allocated for staff and family members, located as far as possible from operating rooms, triage rooms, patient areas, etc. A person responsible for housekeeping and childcare was appointed.

It is clear that the hostilities could lead to disruption of the sewerage infrastructure and the waste collection and disposal process. Therefore, the following measures were promptly taken: outdoor toilets were set up (in a place protected by buildings as much as possible, away from the main routes of patients and the canteen) and pits for garbage and biological waste (16 cubic metres each) were constructed. Lime and chlorine–containing solutions were obtained free of charge from hardware stores.

Given the high probability of fires, the local unit of the State Emergency Service provided the hospital with an additional 20 fire extinguishers and sand to extinguish any possible fire.

The first wounded were brought to the hospital at around 12pm on 24 February. In total, between 24.02 and 11.03.2022, 87 wounded with combat trauma were admitted and provided with medical care.

It is interesting to note that there were no requests for surgical care for other reasons. Therapeutic care was provided to more than 500 patients on an outpatient basis, mostly for manifestations of hypertension and nervous breakdown.

This can be explained by the fact that most of the residents of the settlements in the area of hostilities evacuated in the first days of the fighting, and the movement of the rest was impossible.

Among the wounded, 18 (20.7%) were military personnel and territorial defence participants, while the remaining 69 (79.3%) were civilians.

The minimum time to get a wounded person to a hospital was 20 to 30 minutes, and the maximum time was up to 4 days.

The average age of the wounded was 42 ± 2.7 years. There were 89.2% of men and 10.8% of women.

By the nature of the injuring agent, the distribution of the wounded was as follows: 64 per cent had gunshot wounds and 34 per cent had shrapnel wounds. In 2% of the wounded, the mechanism of injury was different (burns, blast wave).

10 (11.5%) of the wounded had combined trauma (gunshot bone fractures and chest and abdominal injuries), 34...
(39.1%) had skeletal trauma, 6 (6.9%) had isolated injuries to the abdominal and thoracic cavities, and 37 (42.5%) had soft tissue injuries.

Anti–shock measures were carried out simultaneously with diagnostic measures, which, if necessary, were accompanied by ultrasound and radiography directly in the operating room to which the wounded were sent.

Instrumental studies allowed us to obtain information quickly and determine the priority and sequence of surgical care.

At the stage of triage, the wounded were anaesthetised with narcotic and non–narcotic drugs (depending on the nature of the injury): Morphine hydrochloride solution 1% 1 ml intramuscularly, nalbuphine 0.3 mg/kg intramuscularly 3 – 4 times a day, dexketoprofen 2 ml intramuscularly 3 times a day, metamizole sodium 2 ml intramuscularly 3 – 4 times a day, piritramid 100 ml intravenous drip 3 times a day, nefopam 20 mg intramuscularly 3 – 4 times a day, broad–spectrum antibiotics (cephalosporins of the 3rd – 4th generations: ceftriaxone 1 g twice a day, cefepime 1 g intravenously twice a day), and emergency tetanus prophylaxis: purified adsorbed liquid tetanus toxoid 0.5 ml subcutaneously, tetanus toxoid immunoglobulin 250 IU intramuscularly.

Among the surgical interventions performed, the vast majority (47%) were primary surgical treatment of wounds of varying complexity, trauma surgeries with external fixation of skeletal structures were in second place (28%), and operations on the chest and abdominal cavities (9%) were in third place.

Negative pressure therapy, or vacuum therapy, played an important role in the treatment of wounded with gunshot wounds. The use of such therapy allowed to significantly improve the quality of treatment (reduction of pain, promotion of maximum growth of granulation tissue, absence of purulent and septic complications).

It should be noted that the surgical interventions were performed under general anaesthesia, supplemented by conductive local tissue infiltration.

In general, the organisational and administrative measures taken in the first hours after the start of the hostile attack on 24 February made it possible to provide medical care in the hospital 24/7 until its evacuation without significant adjustments [3].

However, due to the operational combat situation, there was a need for constant transformation of measures to ensure the hospital’s life support and medical care [4].

The hospital medical staff lacked the knowledge and experience to provide medical care for combat surgical trauma, so the first 2–3 days of medical triage were carried out separately from anti–shock measures and instrumental examination [5].

The working analysis, review of the relevant literature and consultations with relevant experts of the National Academy of Medical Sciences and the Ministry of Health of Ukraine led to the conclusion that this approach should be changed [6, 7].

The combination of triage with anti–shock measures and instrumental examination made it possible to reduce the time to surgical intervention by (24 ± 5.4) minutes compared to the same period recorded in the first 2–3 days of care for the wounded. In addition, it made it possible to clearly and quickly determine the nature of the gunshot wound and the sequence of further actions.

Given the frequency of delivery of the wounded, if the total number of operated patients increased, specialists from the second team were temporarily assigned to the third team. At the same time, advanced dressings under general or regional anaesthesia required the participation of specialists with the appropriate profile and qualifications.

Of the 87 wounded at the stage of medical triage, no one died, 1 wounded was brought in in an agonised state and received palliative care. The postoperative mortality rate was 1.15% (1 patient died with injuries incompatible with life).

There were no early postoperative complications. Long–term results cannot be analysed as the wounded were transferred to other medical facilities in different regions after the hospital was evacuated.

The hospitalisation of the soldiers necessitated a decision to allocate a separate secure room away from crowds of medical staff and patients for the storage and accounting of weapons, ammunition and documents. Such a room was found and equipped with shelving. The documents and belongings of each patient were described by the commission and handed over to the responsible person from the administrative staff for storage. Similarly, the weapons and ammunition were inventoried and stored in a separate room that was the most remote and protected (with bars, locked) from the staff.

The hospital also had a maternity unit located in a settlement 25 kilometres from Irpin, which provided obstetric and gynaecological and neonatal care to residents of the local community. As a result of the hostilities, pregnant women could not get to the maternity ward and had to go to the hospital. This forced the hospital to set up a midwifery room in one of the operating theatres, which was as far away as possible from the main operating theatres, triage areas and wards, and to set up places for women in labour and babies in the nearest wards. During the period of isolated work, 2 babies were born in the hospital. Therefore, in our opinion, medical institutions that do not have an obstetric unit in their structure, but there is a possibility (in case of emergency response or military operations) of hospitalisation of pregnant women, should provide premises for obstetric and neonatal services.

Communication is essential for the hospital to function and provide medical care. Organisational issues and consultations with specialists from other medical institutions, including the Ministry of Health and the National Academy of Medical Sciences of Ukraine, were resolved through digital communication systems.

As the hostilities resulted in limited digital communication, it was carried out through partially preserved analogue systems (telephone line, fax), which justifies the need for backup analogue communication systems in the medical facility.
After the de-occupation of Bucha, Irpin and Gostomel, the hospital's patients were transferred to other medical institutions in Kyiv to provide further treatment. This was due to the need to restore the destroyed public utilities in these settlements and, accordingly, to establish centralised water supply, power supply and heating of the hospital premises, as well as to carry out counter-terrorism measures and demining.

It is worth noting that if the hospital had continued to operate under the existing conditions for another week, the following issues would have been addressed:
- shortage of sterile linen for operating theatres and bed linen for patients;
- shortage of bandages and medicines;
- shortage of donated blood and its components.

The issue of surgical anaesthesia should be highlighted separately. The stocks of appropriate general anaesthetics (sevoflurane 250 ml 5 vials, sodium thiopental 0.5 g 110 vials, fentanyl 2 ml 1022 ampoules, diprofol 20 ml 436 vials/50 ml 66 vials, ketamine 2 ml 50 ampoules) allowed for general anaesthesia for surgical interventions and extended dressings. At the same time, in case of further massive delivery of wounded, their anaesthetic support could be questionable. One of the solutions to this issue was the active introduction of regional and local anaesthesia in the hospital.

Continuation of the hospital's intensive operation without the functioning of the relevant utilities (household waste and medical waste removal) would require the excavation of additional pits for household and medical waste.

It is important to emphasise another issue – water supply. The rational use of available water reserves in addition to the centralised water supply, which was partially operational, allowed us to provide adequate medical care and ensure the life of the institution. However, given the risks that exist during hostilities, the possibility of mass delivery of the wounded and sick and the long-term operation of the medical facility, there is a need for an alternative water supply source – an artesian well, a high-flow well with a backup autonomous power supply and a separate fuel supply.

In addition, it is advisable to arrange a backup autonomous sewage system (septic tank, cesspool), which, together with a backup water supply source, will make it possible to use the existing water distribution network.

The catering team prepared meals daily for nearly 500 people (63 patients, 87 wounded, about 200 medical staff and 100 family members) staying in the hospital. In order to reduce the workload of this group, especially given the conditions in which they prepared food, family members of medical staff staying in the hospital and volunteers (mostly residents of nearby houses) were involved in the cooking process as much as possible.

Measures to reduce the range of dishes and their portion sizes, as discussed above, made it possible to provide adequate nutrition to patients, medical staff and their families. However, the hospital's isolated functioning for another 7–10 days would have forced the search for food (especially cereals and meat and dairy products).

In view of the above, we believe that it would be advisable for the hospital to have a reserve autonomous catering unit with the appropriate range of products, equipment (depending on the projected number of people who will need food) and food stocks.

A retrospective analysis of the hospital's operations during this period also indicates that it is advisable to keep a reserve set of basic surgical instruments, which should be placed in a separate room.

In general, it should be noted that the organisational measures taken by the administration in the hospital on the first day after the large-scale invasion of Russian troops allowed for an adequate and effective level of medical care to be provided to the victims of the hostilities in an autonomous mode. At the same time, the process of providing medical care and life support measures at the hospital did not require any significant organisational changes in the future.

The response to the new challenges posed by the course of hostilities was only to adjust the basic action plan, not to change it.

The analysis of the hospital's operation in the epicentre of hostilities gives grounds to identify several key organisational and administrative measures to ensure the appropriate level of medical care, safety of patients, medical staff and the overall functional capacity of the medical facility.

1. Availability of several sources of energy supply for the medical facility and an autonomous source of energy supply with an appropriate fuel supply in underground tanks.
2. Availability of an autonomous water supply (water reserves in tanks or an artesian well with an autonomous power supply and fuel supply) and sewerage system.
3. Availability of a backup food unit with a supply of food (cereals, canned food, deep-frozen food, etc.).
4. Availability of a reserve of basic medicines, consumables and instruments at the rate of 200% of the total number of surgical interventions performed in a month in a medical institution.
5. Having a sufficient reserve of blood products and components, if this is not possible, having a sufficient number of tests to detect blood-borne infections and being prepared to use whole blood (after rapid testing) as a last resort to replace blood loss.
6. Preliminary planning for the placement and protection of additional operating units, casualty reception and triage areas, staff and patient facilities, and weapons and ammunition storage.
7. Planning of additional sanitary areas, storage areas for waste (including biological waste) and bodies of the dead.
8. Training of personnel in the provision of medical care to wounded with combat surgical trauma and stress management, as well as the formation of appropriate medical teams.
Having an action plan in place in the event of an armed conflict based on the above measures will allow a healthcare facility to respond promptly to urgent emergency challenges.

Russia's large-scale invasion of Ukraine took place in several directions: from the territory of the Republic of Belarus, across the Ukrainian–Russian border along Chernihiv, Sumy and Kharkiv regions, and from the territory of the temporarily occupied Crimea.

Subsequently, in early April, Russian troops left the occupied districts of Kyiv, Chernihiv and Sumy regions under pressure from the Ukrainian Armed Forces, which made it possible to conduct a preliminary analysis of the organisation of medical care in similar medical institutions during the period of active hostilities in these communities.

In general, the hospital administration and the management of similar medical facilities in Sumy, Chernihiv and partly Kyiv regions had to solve similar basic problems on the first day of the hostilities. However, there was a difference in the functioning of these medical institutions, which primarily concerned the staffing of their activities, namely a pronounced shortage of medical staff. It should be noted that even before the outbreak of hostilities in Sumy and Chernihiv regions, there was a shortage of medical staff, and the vast majority of the staff were doctors of pre-retirement and retirement age (55–65 years old). Therefore, these medical institutions, being in isolated conditions, worked with a significant overload on medical staff and without a clear division into medical teams.

In addition, the armed aggression followed an active scenario, which led to the rapid occupation of the settlements where similar medical facilities were located and made it impossible for local authorities to respond promptly to situational challenges.

In general, the organisational measures taken by the hospital administration can be recognised as optimal. However, they were implemented due to a number of factors: the professional administrative team of the hospital, the general state of the organisation of medical care (availability of staff, medicines, medical equipment, appropriate level and quality of medical care, professionalism of the staff), as well as the prompt response of local authorities, institutions and enterprises.

In addition, from the analysis of the political and social situation and, accordingly, measures to ensure the defence capability of the countries of the European continent (increasing the total number of armed and security forces, increasing defence spending, including the military medical component), it follows that it is advisable to take measures to prepare civilian medical institutions to provide medical care under martial law both directly in the combat zone and for the wounded and injured during the evacuation stages [8, 9]. They can be divided into 3 main groups.

1. Material and technical measures (arrangement of appropriate premises, stockpiling of medicines and consumables, organisation of an autonomous functioning system).
2. Organisational and medical (formation of medical teams, planning of patient routes) and medical (accommodation of staff and patients, deployment of additional triage sites, operating rooms, etc.) logistics.
3. Professional training (training in military medicine and civil defence, protection against weapons of mass destruction, moral and psychological training).

Taking appropriate measures will allow the medical sector to deploy appropriate forces and means to ensure the provision of medical care in the event of a crisis (military operations or natural or man-made disasters accompanied by a significant number of victims) in an operational mode [10].

Conclusions
1. The current geopolitical situation necessitates measures to prepare medical institutions and medical professionals to work in the context of armed conflict, including training on the organisation and specifics of providing medical care to wounded with combat surgical trauma.
2. The experience of the functioning of civilian medical institutions in Ukraine in the context of hostilities should be used as a basis for the development of appropriate plans and measures.
3. The organisational and administrative measures and actions outlined above are necessary to ensure the provision of medical care not only during military operations, but also during possible natural and man-made disasters.

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