



## Telemedicine Consultations for Children with Musculoskeletal Injuries: Data from the Turner National Medical Research Center of Children's Orthopedics and Trauma Surgery

Vyacheslav I. Zorin<sup>1,2</sup>, Sergey A. Lukyanov<sup>1</sup>

<sup>1</sup> H. Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery, St. Petersburg, Russia

<sup>2</sup> Mechnikov North-Western State Medical University, St. Petersburg, Russia

### Abstract

**Background.** Currently, the mortality rate of pediatric patients due to injuries surpasses mortality from other causes worldwide. The selection and timely transfer of the injured to specialized clinics are crucial elements of the healthcare system. Telemedicine consultations (TMC) are considered by several authors as an effective means to enhance the quality of trauma care and optimize patient routing processes.

**Aim of the study** was to analyze the results of urgent and emergent telemedicine consultations and hospitalizations based on telemedicine consultations for children with musculoskeletal injuries.

**Methods.** TMC requests from 2020 to 2022 were analyzed. When evaluating TMC requests, attention was given to the type of request (planned, urgent, emergent), the region from which the request originated, and the correspondence of the request's urgency category to the patient's diagnosis. The study also involved an analysis of the injury structure, its severity according to the Injury Severity Score (ISS) at the time of trauma, and the timelines for requesting and transferring to the federal clinic from the moment of injury.

**Results.** From 2020 to 2022, a total of 3745 requests for TMC were received. Among them, there were 572 urgent and emergent requests. A threefold increase in the number of TMC requests was observed over the span of three years. In the same period, 78 patients were transferred to the clinic. For 36 patients with combined and multiple injuries, the severity of trauma was assessed using the ISS scale. The average score was 31 (min 9; max 57). The average time for regional institutions to send a request from the moment of the patient's hospitalization was 6.7 days. Hospitalization in the center's clinic from the moment of injury was 10.3 days (min 1, max 58).

**Conclusion.** The study revealed the following issues that need to be addressed through further organizational steps: a high percentage of mismatch between the type of request and the actual clinical picture, delayed consultations, prolonged medical evacuation, and organizational aspects of medical evacuation.

**Keywords:** telemedicine, children, injuries of musculoskeletal system, medical evacuation, emergency care, trauma center, disaster medicine.

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✉ Sergey A. Lukyanov; e-mail: [Sergey.lukyanov95@yandex.ru](mailto:Sergey.lukyanov95@yandex.ru)

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## Анализ телемедицинских консультаций детям с повреждениями опорно-двигательного аппарата по данным НМИЦ детской травматологии и ортопедии им. Г.И. Турнера

В.И. Зорин<sup>1,2</sup>, С.А. Лукьянов<sup>1</sup>

<sup>1</sup> ФГБУ «Национальный медицинский исследовательский центр детской травматологии и ортопедии им. Г.И. Турнера» Минздрава России, г. Санкт-Петербург, Россия

<sup>2</sup> ФГБОУ ВО «Северо-Западный государственный медицинский университет им. И.И. Мечникова» Минздрава России, г. Санкт-Петербург, Россия

### Реферат

**Актуальность.** В настоящее время смертность пациентов детского возраста от травм превышает смертность от прочих причин во всем мире. Отбор и своевременный перевод пострадавших в специализированную клинику является важным элементом работы медицинской системы. Телемедицинские консультации (ТМК) рассматриваются рядом авторов как один из эффективных способов повышения качества травматологической помощи и оптимизации процессов маршрутизации пациентов.


**Цель** — провести анализ результатов экстренных и неотложных телемедицинских консультаций и госпитализации по телемедицинским консультациям у детей с травмами опорно-двигательного аппарата.


**Материал и методы.** Были проанализированы запросы на проведение ТМК в 2020–2022 гг. При оценке уделяли внимание типу запроса (плановый, экстренный, неотложный), региону, из которого поступил запрос, а также соответствию категории срочности запроса диагнозу пациента. В ходе исследования проведен анализ структуры повреждений, их тяжести по шкале Injury Severity Score (ISS) на момент травмы, а также сроков формирования запроса и перевода в федеральную клинику с момента получения травмы.

**Результаты.** За 2020–2022 гг. поступило 3745 запросов на проведение ТМК, из них экстренных и неотложных 572. В динамике отмечен рост количества запросов на ТМК более чем в три раза за 3 года. За 2020–2022 гг. в клинику были переведены 78 пациентов. У 36 пациентов с сочетанными и множественными повреждениями проведена оценка тяжести травмы в соответствии со шкалой ISS, средний балл — 31 (min 9; max 57). Средний срок отправки запроса региональным учреждением с момента госпитализации пострадавшего составил 6,7 сут. Госпитализация в клинику Центра от момента получения травмы составила 10,3 сут. (min 1; max 58).

**Заключение.** Были выявлены следующие проблемы, на решение которых должны быть направлены дальнейшие организационные шаги: высокая доля несоответствия типа запроса истинной клинической картине, отсроченные обращения за консультацией, длительность медицинской эвакуации и вопросы ее организации.

**Ключевые слова:** телемедицина, дети, травмы опорно-двигательной системы, медицинская эвакуация, экстренная помощь, травмацентр, медицина катастроф.

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 Лукьянов Сергей Андреевич; e-mail: [Sergey.lukyanov95@yandex.ru](mailto:Sergey.lukyanov95@yandex.ru)

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## BACKGROUND

According to data from the WHO and EuroSafe (European Association for Injury Prevention and Safety Promotion), injuries constitute the leading cause of death and disability among patients aged 1 to 19 years<sup>1,2,3</sup>.

As early as the 1990s, predictions were made that traumatic injuries, particularly those caused by road traffic accidents, would become the main cause of child mortality by 2020, surpassing mortality from infectious diseases<sup>3</sup>. This epidemiological shift reflects the progress achieved in preventing and treating pediatric infections, as well as the absence of highly effective programs focused on trauma prevention and treatment. Some studies reveal that residents of sparsely populated regions face risks of both traumatic injuries and high mortality due to trauma, often resulting from insufficient access to medical care. This issue is not specific to the Russian Federation alone.

Research indicates that treatment outcomes for trauma patients, especially children, are significantly better when conducted promptly in specialized centers equipped with trained personnel and modern resources. Due to socioeconomic constraints, this provision is challenging in remote regions. Compared to patients injured in urban areas, patients from rural areas have fewer chances of receiving treatment at trauma centers, and their risk of fatality is twice as high [5, 6, 7, 8].

Possible reasons for patients with traumatic injuries not promptly accessing appropriate specialized care include delays in notifying or transporting emergency medical services, significant distances between the injury site and the nearest trauma center, difficulties in determining treatment strategies by regional medical professionals, patients' preference to stay close to their families, and several other factors [5, 9]. Limited human and technological resources can lead to delays in diagnosis and necessary treatment, misguided tactics, and an increase in inter-institutional transfers before a patient is eventually admitted to a specialized department [10].

In recent years, one of the potential solutions to address some of these issues has been the widespread adoption of real-time telemedicine consultations (TMC) or consultations within regulated time frames. This approach aims to enhance the quality of trauma care [11, 12, 13].

Therefore, the question of digital consultative interaction between institutions of different levels that provide emergency and urgent care, particularly for pediatric trauma patients, taking into account the geographical features of the Russian Federation, is extremely relevant.

*Aim of the study* is to analyze the outcomes of urgent and emergent telemedicine consultations and subsequent hospitalizations based on telemedicine consultations for children with musculoskeletal injuries.

## METHODS

### *Study design:*

the study employed a retrospective, single-center design with a retrospective depth spanning from 2022 to 2020.

In accordance with the Russian Ministry of Health Order No. 965n "On the Approval of the Procedure for the Organization and Provision of Medical Assistance Using Telemedicine Technologies," a telemedicine system for remote consultations at federal and regional levels was established in the Russian Federation (<http://tmk.minzdrav.gov.ru/>). The order outlined three forms of telemedicine consultations (TMC):

- Emergency form: for sudden acute illnesses, conditions, exacerbation of chronic illnesses posing a threat to the patient's life. Response time: 30–120 minutes from the time of the request.
- Urgent form: for acute conditions, exacerbation of chronic illnesses without evident life-threatening signs. Response time: 3–24 hours from the time of the request.
- Planned form: for preventive measures, diseases and conditions not accompanied by a threat to the patient's life, not requiring emergency or urgent medical care. Initiating TMC according to this normative document is the responsibility of the attending physician.

<sup>1</sup> Child Safety Report Card 2009: Europe Summary for 24 Countries. Published online 2009. [https://webgate.ec.europa.eu/chafea\\_pdb/assets/files/pdb/20101212/20101212\\_d1-00\\_oth\\_en\\_ps.pdf](https://webgate.ec.europa.eu/chafea_pdb/assets/files/pdb/20101212/20101212_d1-00_oth_en_ps.pdf). Accessed January 15, 2023.

<sup>2</sup> CDC Injury fact book. Published online 2006. Available from: <https://stacks.cdc.gov/view/cdc/11438>. Accessed January 15, 2023.

<sup>3</sup> The Global burden of disease : a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020 : summary / ed. by Ch.J.L. Murray, A.D. Lopez. Available from: <http://apps.who.int/iris/handle/10665/418643>.

Since 2020, the Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery has been participating in consultative activities through the aforementioned system.

A comprehensive analysis of requests in the telemedicine system for remote consultations at federal and regional levels was conducted, followed by a selection based on the following inclusion criteria:

- Diagnosis according to ICD-10 nomenclature corresponding to class XIX: injuries, poisonings, and certain other consequences of external causes (S00-T98).
- Pediatric age (up to 18 years).
- Consultation profile: "pediatric traumatology and orthopedics."
- Type of request: planned, urgent, emergency.
- Availability of complete information for consultation (medical documentation, radiological archive).

Furthermore, when evaluating requests in the system, attention was given to the region, the correspondence of the urgency of the request to the patient's diagnosis, the localization of injuries, an assessment of the severity using the Injury Severity Score (ISS) at the time of trauma, and the time intervals from injury to request formation and transfer to the Federal Center.

### Statistical analysis

The obtained data were analyzed using StatTech v. 3.1.6 software (StatTech, Russia) and Microsoft Excel. Categorical variables were described with absolute values and percentages. Comparison of groups based on quantitative variables was performed using the Mann-Whitney U test. Comparison of percentage distributions in the analysis of multinomial contingency tables was conducted using Pearson's  $\chi^2$  test.

## RESULTS

During the period of 2020–2022, a total of 3745 requests for TMC were received, including 572 urgent and emergent requests (Table 1).

Upon analyzing the number of TMC requests by year, a cumulative threefold increase was observed over the span of three years, including a twofold increase in urgent and emergent conditions. It's worth noting that while the total number of requests continued to rise in 2022, the

count of urgent and emergent requests slightly decreased. However, an analysis of this category of requests revealed a substantial frequency of mismatch between the content of the request and its urgency category. The regression of this mismatch was observed in 2022.

Requests not matching the urgency category pertained to planned conditions related to long-standing orthopedic pathologies of the musculoskeletal system without signs of acute progression or significant deterioration in the patient's condition.

The structure of TMC requests, matching the urgency criteria, based on the location of the injury is presented in Table 2.

*Table 1*  
**Structure of telemedicine consultation requests in 2020-2022**

| Type of consultation request             | 2020          | 2021           | 2022           |
|--|---------------|----------------|----------------|
| Planned                                  | 465           | 999            | 1709           |
| Urgent mismatch to request type, n / %   | 56<br>22/39.3 | 162<br>74/45.6 | 133<br>39/29.3 |
| Emergent mismatch to request type, n / % | 48<br>21/43.8 | 90<br>45/50    | 83<br>25/30.1  |
| Total TMC including urgent + emergent    | 569<br>18.3%  | 1251<br>20.1%  | 1925<br>11.2%  |

*Table 2*  
**Structure of requests based on injury localization in patients with trauma**

| Injury localization            | Number of patients, n (%) |
|--------------------------------|---------------------------|
| Multiple and combined injuries | 65 (18.7)                 |
| Maxillofacial trauma           | 6 (1.8)                   |
| Extremity injuries             | 199 (57.6)                |
| Pelvic injuries                | 17 (4.9)                  |
| Spinal injuries                | 59 (17.0)                 |

The geography of regional specialist consultations with the labels of urgent and emergent requests (351 and 221, respectively) covered 78 regions. Notably, a significant number of requests came from relatively sparsely populated regions. Table 3 provides the regions of the Russian Federation from which the highest number of urgent and emergent TMC requests were received.

The structure of request causes encompassed combined and multiple injuries as well as isolated injuries.

Table 3

**Russian regions with the highest number of telemedicine consultation requests in "urgent" and "emergent" categories**

| Region                         | Number of requests |
|--------------------------------|--------------------|
| Kamchatka krai                 | 36                 |
| Kursk region                   | 25                 |
| Yamalo-Nenets autonomous okrug | 23                 |
| Lipetsk region                 | 20                 |
| Chechen republic               | 18                 |
| Kaliningrad region             | 18                 |
| Voronezh region                | 17                 |
| Republic of Bashkortostan      | 14                 |
| Krasnodar krai                 | 14                 |
| Penza region                   | 13                 |

Starting from 2021, the Turner National Medical Research Center for Children's Orthopedics and Trauma Surgery established a service for providing assistance to children and adolescents with musculoskeletal injuries requiring high-tech medical care, as well as consultative support for regional specialists on various types of musculoskeletal injuries, operating around the clock daily. Based on the results of urgent and emergent telemedicine consultations during the period of 2021–2022, 78 patients were hospitalized at the center (46 in 2021, 32 in 2022). The average age of the patients was 13.2 years (min 4, max 17). For patients with combined injuries (36 children), an evaluation using the ISS scale was

performed, with an average score of 31 (min 9, max 57). Additionally, the hospitalized patients' types of trauma were analyzed (Figure 1). Cases of attempted suicide among children and adolescents were categorized as domestic injuries. Statistical analysis revealed a significant difference between patients with isolated and combined injuries ( $p = 0.019$ ) — domestic injuries, primarily suicide attempts (self-inflicted injuries), were more prevalent among patients with combined injuries.

The structure of injuries based on their localization among patients admitted to the Center as a result of TMC is presented in Table 4.

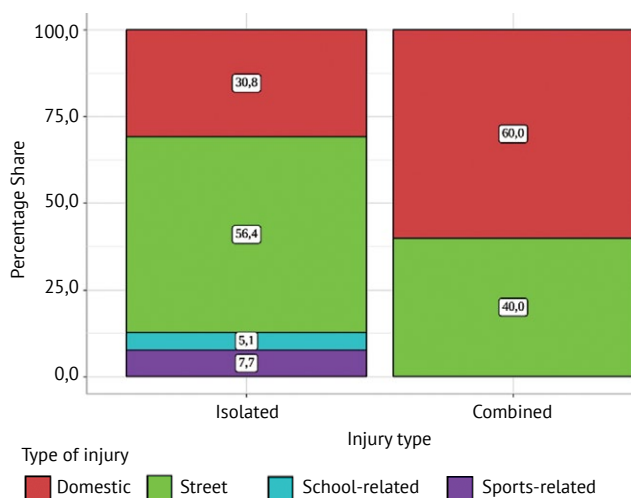


Fig. 1. Analysis of injury type in patients with isolated and combined injuries admitted to the Center.

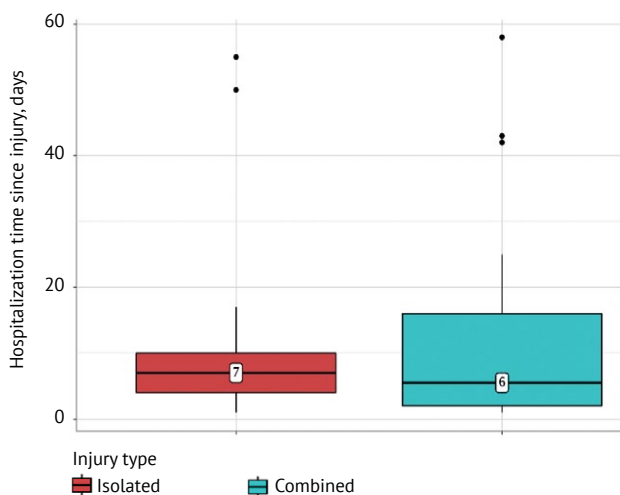
Table 4

**Structure of injuries in patients hospitalized at the center**

| Injury localization            | Number of patients, n (%) |
|--------------------------------|---------------------------|
| Multiple and combined injuries | 28 (36)                   |
| Maxillofacial trauma           | 3 (4)                     |
| Chest injuries                 | 1 (1)                     |
| Pelvic injuries                | 5 (7)                     |
| Spinal injuries                | 15 (19)                   |
| Extremity injuries             | 26 (33)                   |

The average time between the occurrence of trauma and urgent or emergent TMC requests was 6.7 days (min 1, max 45; Q1–Q3 = 1–8). Notably, the average time for TMC requests related to isolated injuries was 5.5 days (min 1, max 45; Q1–Q3 = 2–5), while for multiple and combined injuries, it was 7.8 days (min 1, max 38; Q1–Q3 = 1–10). Although statistical analysis did not reveal significant differences in TMC request times between patients with isolated and combined injuries ( $p = 0.624$ ), there was a noteworthy dissociation between the complexity of the clinical situation and the timing of the consultation request, including the determination of the rational patient management approach.

The average time between trauma and admission to the Center was 10.3 days (min 1, max 58; Q1–Q3 = 2–12). Out of the 78 patients, 42 (54.4%) were medically evacuated by local medical organizations. For the remaining 36 patients (45.6%), transportation was organized by relatives, with the delivery distance exceeding 500 km in 23 cases. A comparative analysis of admission times to the Center between patients with isolated and combined injuries did not reveal significant differences ( $p = 0.976$ ) (Figure 2). This could possibly indicate organizational factors that may override or outweigh clinical considerations.



**Fig. 2.** Time interval between injury and admission to the Center clinic

## DISCUSSION

Over a span of three years, more than 3000 TMC (Telemedicine Consultation) requests were received, and their numbers continue to rise. These data provide insight into the demand for the system within regional institutions specializing in "pediatric traumatology and orthopedics." This mode of operation is relatively novel. This might account for the significant number of false urgent and emergent TMC requests. Additional potential reasons could include the regional specialists' desire to obtain conclusions in the shortest possible time, even for planned pathological conditions, or their lack of awareness about the operational protocols of the telemedicine system. With the passage of time, this operation is gradually being streamlined, but their incidence remains substantial – around 30%.

The geography of urgent and emergent consultations covered virtually the entire country (78 regions). The Kamchatka Krai emerges as the leader in urgent and emergent TMC requests, likely due to several factors such as demographic (low population density), workforce availability, geographical isolation from other regions, and the absence of direct overland communication.

In the analysis of patients admitted to the center based on TMC results, the significance of this format for patients with multiple and combined injuries, constituting half of the hospitalized cases, was established.

Attention is drawn to the prolonged time intervals for generating requests from the moment of trauma, which, in our perspective, do not significantly correlate with the severity and complexity of the injuries. This aspect holds importance in the treatment of skeletal injuries in children, where early surgical intervention is optimal before active consolidation processes occur in a malposition, thus increasing the trauma associated with surgical procedures.

Data indicate the absence of significant differences in the hospitalization periods between patients with combined and isolated injuries. For certain injuries (complicated spinal, pelvic, and sacral injuries), delayed surgical treatment is less effective and less safe in terms of the risks of various complications.

Based on the data obtained, no objective reasons explaining the extended time frames for seeking consultation were identified. It seems logical that complex clinical situations would require early collective discussions. However, the average time for generating requests for children with injuries, according to our data, was 6.7 days. Presumably, this question of transferring to a specialized center for surgical treatment arises as the patient's condition stabilizes. In our opinion, an optimal model for resolving tactical and clinical issues within a unified system is preferable, implemented in a timely manner rather than sequentially, which overall prolongs the timeframe for providing assistance.

According to specialists experience reflected in scientific research, the application of telemedicine technologies facilitating rapid interaction between regional institutions and clinical specialized trauma centers helps reduce the number of transfers between institutions, the overall duration of hospitalization, and the number of non-essential diagnostic procedures [13,14]. Furthermore, unwarranted delays in transfer significantly deteriorate treatment outcomes [15, 16]. Considering the obtained data and literature findings, the enhancement of TMC services for urgent and emergent conditions should be pursued jointly with the development of regulated routing algorithms and patient transportation between institutions, ultimately forming a coordinated system for providing assistance to patients with trauma, considering the geographic conditions of the region and the country as a whole [14, 17, 18].

In summary, the implementation of the TMC system in the domain of "pediatric traumatology and orthopedics," as evidenced by the analysis, has demonstrated its demand, progressively increasing quantitatively from year to year. It has facilitated prompt interaction between specialized centers and all regional institutions across the country. Nonetheless, certain pertinent issues have emerged:

Improving the quality of formulated consultative requests (matching the category, providing a comprehensive amount of information: radiographic archive, medical documentation).

Extended time frames for generating requests for injuries requiring high-tech treatment, including within specialized centers.

The problem of organizing transportation and medical evacuation of patients to a specialized center is identified as the ultimate element of consultation effectiveness.

## CONCLUSION

The telemedicine consultation system, as proven by practical experience, is a widely sought-after and effective element of operational collaboration between federal and regional institutions in providing assistance to children with musculoskeletal pathologies. This aspect is particularly crucial considering Russia's vast geography and overall plays a positive role in enhancing the efficiency and quality of specialized urgent assistance, including high-tech assistance, to the pediatric population in the domain of "traumatology and orthopedics." The analysis conducted has outlined certain challenges related to the quality of requests, the timing of their submission, and the process of patient transfer and transportation. Evidently, these matters lie within the interests and responsibilities of the professional community and are also within the realm of organizational decisions, including at the interdepartmental level.

## DISCLAIMERS

### *Author contribution*

*Zorin V.I.* — study concept and design, data collection and processing, writing and drafting the article.

*Lukyanov S.A.* — literature search and analysis, data collection and processing, writing the article.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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**Ethics approval.** Not applicable.

**Consent for publication.** Not required.

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## Authors' information

✉ Sergey A. Lukyanov

Address: 64-68, Parkovaya st., St. Petersburg, Pushkin, 196603, Russia

<https://orcid.org/0000-0002-8278-7032>

e-mail: [Sergey.lukyanov95@yandex.ru](mailto:Sergey.lukyanov95@yandex.ru)

Vyacheslav I. Zorin — Cand. Sci. (Med.)

<https://orcid.org/0000-0002-9712-5509>

e-mail: [zoringlu@yandex.ru](mailto:zoringlu@yandex.ru)