

**Chronic posttraumatic osteomyelitis of the humerus:  
economic aspects of treatment with the method of transosseous osteosynthesis  
method using the Ilizarov fixator**

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**Objective** To review economic aspects of treatment of patients with chronic posttraumatic osteomyelitis of the humerus. **Material and methods** Cost-effectiveness of treatment of chronic posttraumatic osteomyelitis of the humerus using the method of transosseous osteosynthesis with the Ilizarov apparatus was evaluated. Medical expenses were compared with standard financial expenditures as established by regulations of medical assistance provided to the patients with osteomyelitis. **Results** Treatment of patients with the method of controlled transosseous osteomyelitis being highly effective, have shown to entail considerable economic losses due to the severe pathology, multiple stages of previous treatment performed untimely and inadequately. **Conclusions** Economic losses can be reduced through thorough preadmission examination of patients including bacterial culture and antibiotic sensitivity tests, decreased preoperative period, optimal choice of treatment tactics and quality care, to be followed by outpatient course.

**Keywords:** surgical infection, economic costs, economic losses, osteomyelitis, transosseous osteosynthesis, humerus, lost profits, medical expenses

## INTRODUCTION

Treatment of patients with osteomyelitis involves both medical and socio-economic issues [1, 2, 3, 4]. Posttraumatic osteomyelitis accounts for 6.5% of all musculoskeletal disorders. Recurrent episodes of osteomyelitis are reported to occur in 15-30 % of postoperative cases [5, 5, 7, 8]. Chronic osteomyelitis is defined as a long-standing and severe condition that can lead to a long-term disability and considerable expenses needed

for the treatment of a patient [9]. Awareness of the extent of the problem is important for executives of medical institutions, medical insurance funds from both medical and economic aspects [10]. However economic aspects can be rarely found in the literature.

**Objective** To review economic aspects of treatment of patients with chronic posttraumatic osteomyelitis of the humerus.

## MATERIAL AND METHODS

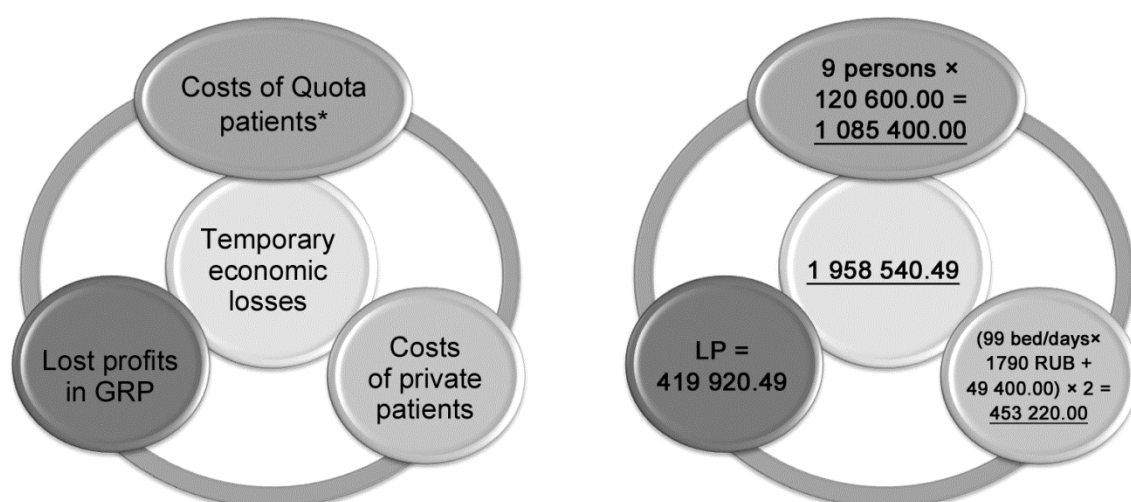
Temporary and permanent economic losses were calculated in treatment of 26 patients with chronic posttraumatic osteomyelitis based on statistic information, established standard funds for rendering High-Technology Medical Assistance (HTMA) per unit and price list of medical services in the years of 2011-2013 using "Calculation Methodology of Economic Losses from Mortality, Morbidity and Disability in the Popula-

tion". The study group included 11 patients of working age (4 persons were employed in manufacturing prior to injury and 7 intangible commodities), 8 retired persons and 7 persons with a level 2 disability. Actual costs of treatment of the study group were calculated in the years of 2011-2013. All the patients underwent monofocal acute compression osteosynthesis for a bone defect of 1 cm to 2.5 cm [6].

## RESULTS AND DISCUSSION

Economic losses in chronic posttraumatic osteomyelitis of the humerus could be subdivided into temporary and permanent. Temporary economic losses are associated with costs involved in treatment and inpatient stay of persons of working age with no disability (**Fig. 1**).

These patients were able to return to their jobs and continue contributing to gross domestic products (GDP) following appropriate treatment at the hospital. We employed gross regional product (GRP) for calculations to determine economic losses in the region only.



**Fig. 1** Temporary economic losses: \* Quota patients are the patients who receive treatment at the hospital for the funds of the federal budget

Costs of treatment and inpatient stay of 9 patients made 1 085 400 RUB covered by the funds of the federal budget. Costs of treatment and inpatient stay of 2 private patients made 453 220 RUB. Due to income-yielding activity (99 bed-days (average period of inpatient stay) × 1790 RUB. (cost of 1 bed-day) + 49400 (cost of surgery) = 226610 RUB/one patient).

Using formula for lost profits according to "Calculation Methodology of Economic Losses from Mortality, Morbidity and Disability in the Population" [11] we determined the formula for the lost profit in GRP (amount of GRP underproduced) because of the patients' temporary absence (disease) in manufacturing or intangible commodities without identifying either 'a gender' or 'a reason of disability'; it is as follows,

$$LP = \frac{DTDS \times N_w \times GRP}{Nt \times 365 \times N_e} \quad (1),$$

where  $LP$ , lost profits in GRP (amount of GRP underproduced) due to the disease;  $DTDS$ , days of temporary disability status (average number of bed-days);  $N_w$ , number of working-age patients;  $Nt$ , total number of

study patients;  $N_e$ , number of economically active population of the Kurganskaya Oblast, 2013;  $GRP$  – gross regional product in Kurganskaya Oblast, 2013 [12].

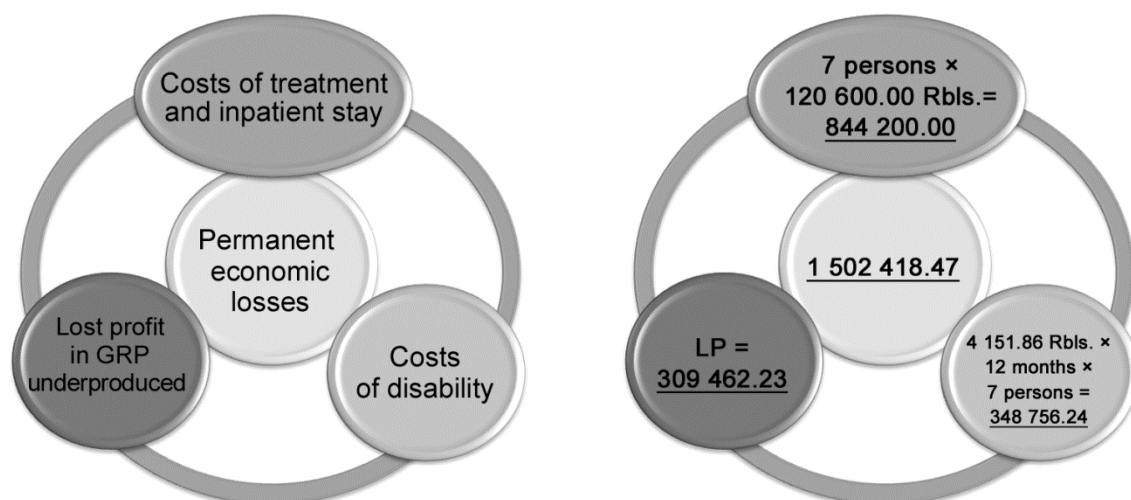
$$LP = \frac{99 \times 11 \times 136508500000}{26 \times 365 \times 410343} = 38174.59 \text{ RUB}$$

Lost profits in GRP due to temporary sickness absence of 11 working-age patients in the labour market amounted to 419920.49 RUB.

Temporary economic profits per 1 patients with posttraumatic osteomyelitis of the humerus amounted to 178049.14 (1958540.49 / 11) RUB.

Permanent economic profits included those associated with a lost ability of a patient to work (disability) (Fig. 2).

The study group included 7 patients with a level 2 disability. Economic losses of invalidity were determined as a difference between GRP that could have been created by persons who became disabled and GRP that were created by persons with disability of a certain level of employment, reduced working hours and longer disability leave.



**Fig. 2** Permanent economic profits

Lost profits in GRP (amount of GRP underproduced) due to absence of a disabled person in manufacturing and intangible commodities were calculated according to the formula [11],

$$LP = \frac{GRP}{Ne} (1 - Ca) \quad (2),$$

where LP, lost profits in GRP (amount of GRP underproduced) due to disability; GRP, gross regional product in Kurganskaya Oblast, 2013; Ne, number of people employed in Kurganskaya Oblast, 2013; Ca – adjustment coefficient for reduced working hours and longer disability leave.

$$LP = \frac{136808500000}{410343} (1 - 0.8674) = 44208.89 \text{ RUB}$$

Annual lost profits in GRP underproduced due to disability amounted to 44208.89 RUB per one person with a level 2 disability. This amount was 309462.23 RUB per year with 7 persons with a level 2 disability being in employment.

Disability costs are associated with monthly payment of disability pensions. In 2013 the disability basic pension amounted to 3610.31 RUB [13] for persons with a level 2 disability, and with reimbursement of 15 % for employment in a region with specific weather conditions monthly payments were 4151.86 RUB for these people of Kurgansky Oblast. So, annual costs of pensions paid to the 7 patients with a level 2 disability amounted to  $4151.86 \times 12 \times 7 = 348\,756.24$  RUB, and costs associated with treatment and inpatient stay (based on established standard expenses to render high-technology medical assistance per unit) included  $7 \times 120\,600 = 844\,200$  RUB.

Annual permanent economic losses amounted to  $214\,631.21 = 1\,502\,418.47 / 7$  RUB per patient.

Therefore, economic losses in patients with chronic posttraumatic osteomyelitis of the humerus amounted to

more than 3 000 000 RUB.

A comparative analysis of hospitalization length, cost of treatment, and expenditures for treatment of patients at infection trauma and orthopaedic department No 2 were compared with established standard of medical assistance rendered to osteomyelitis patients № 520 [14]. Standard expenditures for treatment included medications, dressing and expendable materials as assigned to the standard in market values of 2013 without high-priced expendable materials (implants and other implantable items). Actual costs of medications, dressing and expendable materials were shown to be three times the established standard (Fig. 3).

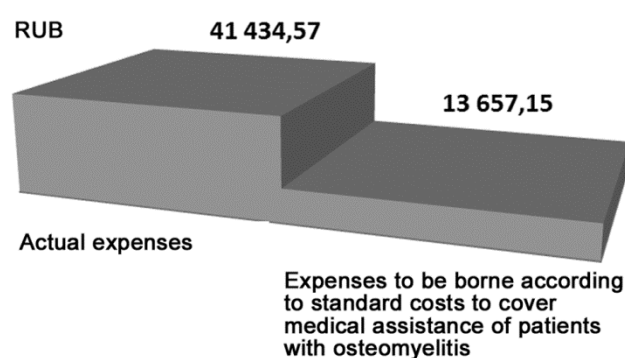


Fig. 3 Costs of medications and expendable materials per one patient

A variety of microflora was found with bacteriological study of purulent nidus of 25 patients (96 %) of the study group that resulted in inpatient period extended by 22 bed-days on average. The greater inpatient increase of 37 bed-days was seen in patients with infection caused by *Pseudomonas aeruginosa*. Minimal increase of 14 bed-days was observed with MRSS, that finally led to increased costs (Fig. 4). The costs per 1 bed-day calculated without profit ratio amounted to 1 492.00 RUB.

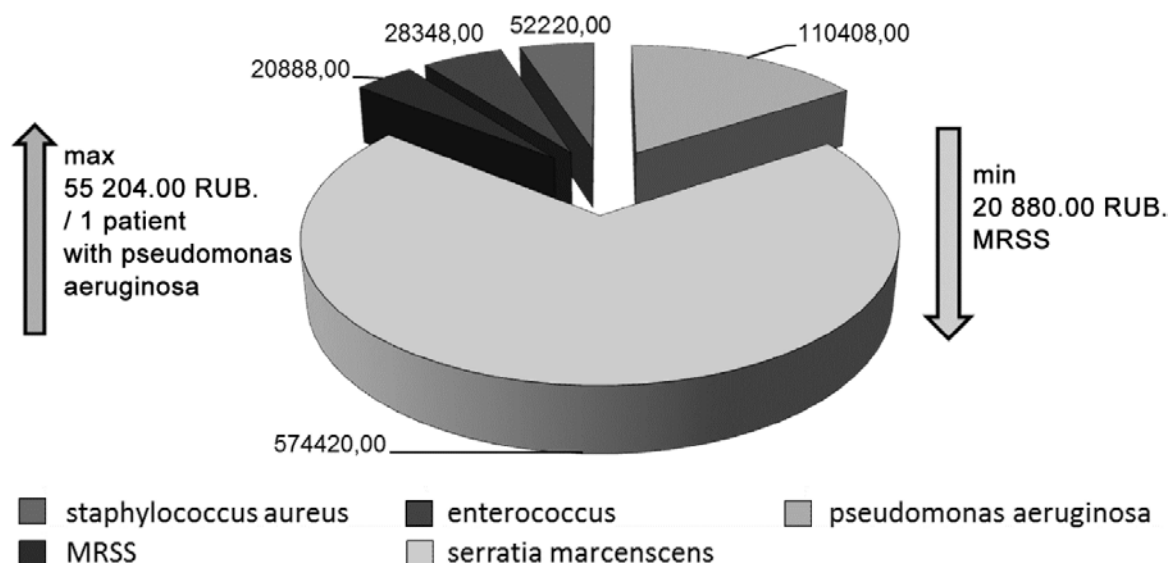
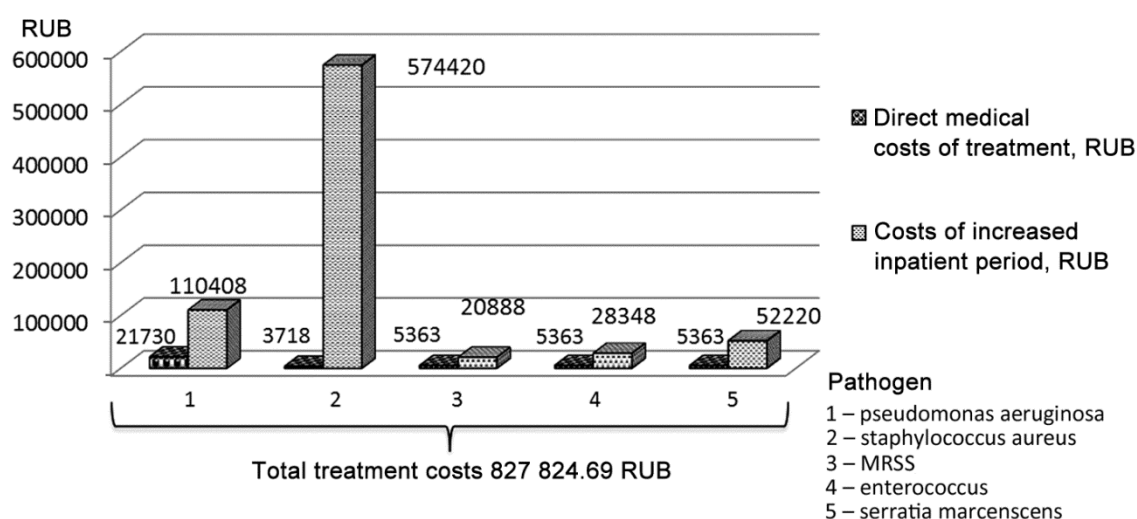


Fig. 4 Expenditures borne due to extended hospitalization period of treatment

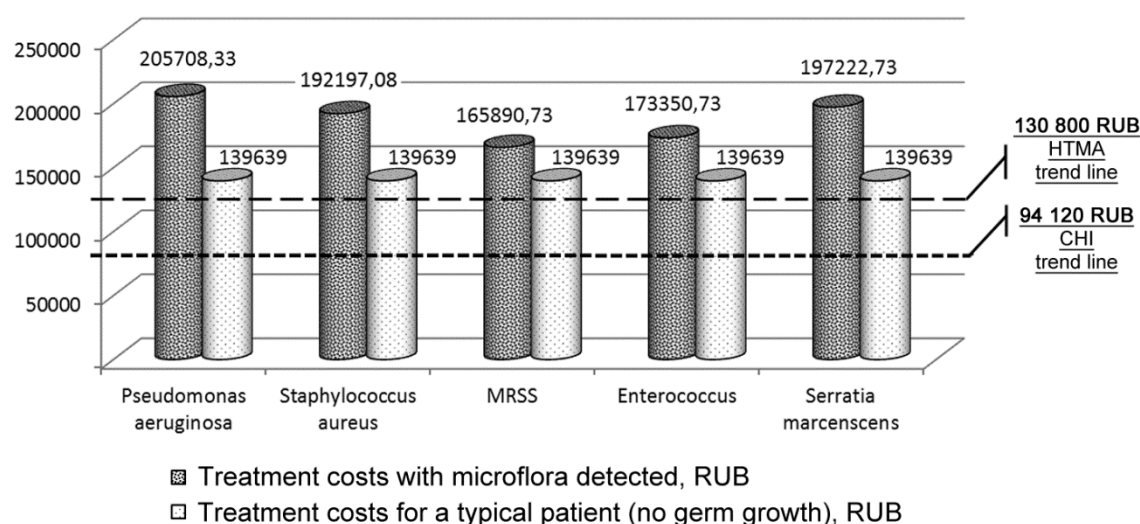
Treatment costs were calculated with increased inpatient stay of the patients of this cohort depending on the type of microflora isolated (**Fig. 5**).

Comparative analysis was performed for treatment costs for a typical patient with the nosological form,

treatment costs for a patient with detected microflora covered with established standard funds for rendering High-Technology Medical Assistance (HTMA) per unit and rates per completed treatment of the disease covered with Complete Health Insurance (CHI) (**Fig. 6**).



**Fig. 5** Costs of treatment with regard to the type of germ



**Fig. 6** Comparative analysis of treatment costs with established standard expenditures

## DISCUSSION

Chronic posttraumatic osteomyelitis causes considerable damage to health systems of both developing and developed countries [7, 9] according to the studies performed by R.J. Rubin et al (2000). Direct medical costs per one patient were reported to be higher for community-acquired infection as compared with hospital-acquired cases (USD35 300 and USD28 800, correspondingly). The authors calculated direct medical costs of inpatient treatment with various types of microflora. *Staphylococcus aureus* associated healthcare costs amounted to USD 35 100 per one patient with osteomyelitis. MRSS associated healthcare costs amounted to USD 34 000 per one patient, that were less by 3 %

[15, 16]. The results of the studies obtained in Taiwan, India, Belgium by several authors showed chronic osteomyelitis being a considerable economic burden for healthcare systems. Extra costs were similar for patients with hospital-acquired infections in Taiwan community hospitals and the medical centre (mean USD 5 335 vs. USD 5 058, respectively) [17]. The study carried out in a tertiary care centre in India determined the costs associated with hospital-acquired bacteraemia amounting to mean US \$14 818 [7]. Patients with a hospital-acquired bacteraemia in a Belgian hospital experienced a significantly higher cost, an average 12 853 euro [18]. According to the exchange rate in 2013 the costs in RUB

ranged from 168 425.95 RUB in Taiwan community hospitals to 1 114 421.00 RUB in the USA. In our study maximum healthcare expenditures per one patient with chronic posttraumatic osteomyelitis of the humerus amounted to 205 708.33 RUB. It showed high economic efficacy with the method of transosseous osteosynthesis using the Ilizarov fixator applied for treatment of the condition.

It should be noted that the authors reported no etiology of osteomyelitis, age of the patients and involvement area. In his study, A.I.Khasanov calculated direct healthcare costs of acute odontogenic osteomyelitis of mandible in children that amounted to 72 000 RUB. [19]. Wakefield D.S. et al. found the method of Appropriateness Evaluation Protocol useful to estimate additional days of hospital stay due to nosocomial infections [20]. Using the method they could identify specific days

of hospitalization. An average length of stay of patients was 52%. According to different authors average length of hospital stay of patients with different microflora was shown to increase from 11.3 to 20.1 bed-days [7, 17, 21]. In our study average length of hospital stay increased by 22 bed-days that was comparable with the above figures.

Hospital costs attributable to staphylococcus aureus, pseudomonas aeruginosa, serratia marcescens, enterococcus were also calculated during the study. No reports were found in the literature review to evaluate hospital costs with the above germs.

Identifying social losses the authors neglected disability related costs due to the disease [16]. No significant differences in social and economic losses due to posttraumatic osteomyelitis were revealed with findings of other authors.

## CONCLUSION

Although the method of controlled transosseous osteosynthesis has shown to be highly effective for patients with chronic posttraumatic osteomyelitis of the humerus it entails considerable economic losses due to the severe pathology, advanced impairment, multiple stages of previous treatment often performed untimely and inadequately.

Therefore, more efforts should be made to pursue new approaches, develop new ideas for improving the quality of specialized and high-technology medical assistance to be performed timely to the patients with chronic posttraumatic osteomyelitis. The method of

controlled transosseous osteosynthesis is very practical in addressing the issues comprehensively during one stage of treatment: arrests the infection, restores the bone integrity and enables to regain function of the segment. Economic losses can be reduced through a thorough preadmission examination of patients including bacterial culture and antibiotic sensitivity tests, decreased preoperative period, optimal choice of treatment tactics and quality care, to be followed by outpatient course.

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