Modeling the Growth of Service Centers Due to the Impact of Recommendations

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Abstract: The relevance of the work is related to the importance of quickly attracting customers to new service centers. Since the efficiency of ensuring this process through promotion is rapidly decreasing, it is important to organize the attraction of consumers through recommendations. The purpose of the work is mathematical modeling of the process of increasing the number of clients in service centers, taking into account the influence of recommendations of different types of consumers, using the example of Therapeutic and physical rehabilitation (TPR) clinics. It is shown that the maximum number of clients of service centers is directly proportional to the promotion activity and the recommendation parameter (R). The greatest influence on the recommendation parameter is exerted by the duration of use of the service by clients. At the same time, negative reviews can have less influence on the growth rate of the number of clients. The recommendation parameter can take negative values and in this case the dynamics of the number of clients becomes rapidly growing - exponential. Promotion management allows for rapid growth in the number of clients to the required level, and then the transition to an economical promotion mode without reducing the number of patients. The conducted research of the dynamics of the recommendation parameter in relation to the TPR clinic show that its value changes several times during the year and averages 13. Thus, customer recommendations increase the flow of patients many times over compared to that generated by promotion. The results of the work can be used to optimize promotion and recommendation activities in growing service and product supply centers, including the growth in the number of clients of new bank branches and Web sites.

1 INTRODUCTION

Economic agents that provide their services to consumers are extremely interested in a stable flow of clients, since this is the basis for their profitability. In particular, this is relevant for network organizations that create new centers of their network and must predict the speed of their growth and the time when it is possible to move on to the creation of new centers.

This work was initiated in connection with the development of a model for the growth of the number of patients in network clinics for the rehabilitation of

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musculoskeletal diseases. At the same time, based on the input-output model (Blackmon, 2004), basic equations of the mathematical model of the recommendation process (Prichina, 2023) were developed, which is much more universal than required to solve the original problem. This model is based on the analysis of the interaction between the outputs and inputs of an economic agent. Patients undergoing treatment recommend the service or product received to their friends, which can multiply the flow of consumers at the entrance to the clinic.

In the work (Karanashev, 2024), the study of this mathematical model was continued, including the concept of a "recommendation parameter" – R was proposed , an analytical solution of the differential equation for the flow of patients to the clinic was obtained, and the exponential dynamics of the number of patients with negative values of R was investigated .

The resulting mathematical model is easy to apply to organizations in various fields of activity, where there is a dynamic process of growth of the consumer flow under the influence of promotion and recommendations of clients. These can be new bank branches, new chain stores and even Web sites.

In fact, this model refers to recommendation marketing. Due to the fact that traditional promotion channels are losing their effectiveness, the role of recommendation marketing is currently rapidly increasing. Aggressive marketing seeks to impose its opinion on the product, which causes a negative reaction from consumers. People trust recommendations from people they know to a much greater extent (up to 90%) (Martensen, 2016).

A number of authors consider in the system of recommendatory agents, first of all, those whose actions can be influenced by paying for their services: opinion leaders, brand blogging, citizen journalism, community marketing (Tatarinov, 2019), various aggregators and even ratings.

In this paper, attention is paid primarily to spontaneous recommenders. Their advantage for an economic agent is that they act free of charge and based on personal experience of receiving a service or product.

However, they can also give negative feedback. Their recommendations are positive if the service is really good. Thus, spontaneous recommendations play the role of orderlies, improving the business ecosystem. In turn, organizations implementing planned measures for recommendation marketing are forced to change the culture of staff attitudes to consumers in such a way as to deservedly receive positive feedback from consumers.

The aim of the work is mathematical modeling of the process of growth in the number of clients in service centers, as well as the study of consumer flows under the influence of recommendations in practice.

2 RESEARCH METHODOLOGY

The paper uses the methodology of recommendation marketing, system and operational approaches. The calculation scheme is based on the input-output operation model (Blackmon, 2004), which includes inputs, outputs, the transformation process and feedback. Numerical and mathematical modeling methods are used (Prichina, 2023). To determine the components of the recommendation parameter, surveys and reports of the organization's departments on customer acquisition channels, as well as publications of recommendation marketing specialists, are used.

2.1. Basics of methodology and information on recommendation marketing

There are several terms used in relation to recommendation marketing: word of mouth, word of mouth marketing, word-of-mouth marketing, or WOM for short (Huete-Alcocer, 2017), and others.

One of the leading experts in recommendation marketing (Berger, 2014) notes that between 20% and 50% of purchasing decisions are influenced by personal recommendations.

J. Berger also analyses where personal recommendations come from. In his opinion, those who believe that electronic information channels are the source are wrong. They provide only about 7% of personal recommendations. The average person spends about two hours a day on social networks and eight times more offline, where there are significantly more opportunities for personal communication.

Another classic in this field is A . Sernovitz estimates that online recommendations account for 20%, and 80% comes from personal interactions (Sernovitz, 2015). He also calls word of mouth a new social force that rewards those companies that give people good products or services and deprives those that make people uncomfortable of sales.

According to statistics (Chichmeli, 2010), to choose a purchase, a client needs to receive 5-6 positive reviews. At the same time, a promoter can give 3-4 such recommendations, and each detractor -

4-6 negative responses, and negative reviews are approximately 5 times more effective. Therefore, one detractor can deprive a supplier of approximately five new clients.

E. Rosen believes it is important to divide all recommenders, primarily into promoters and detractors (critics). The former are more likely to recommend your services, while the latter are unlikely to. Both of these groups include those who have personally used these services and rely on the opinions of others (Rosen , 2013). He recommends, first of all, increasing the number of promoters who have personal experience using the products. It is also important to study the opinions of detractors who have had personal experience. They will help to study and eliminate the problems of your company's products. Among clients, there is also a passive group

F. Reichheld calls for the creation of a new system of indicators for accounting for the efficiency of a company's activities (Reichheld, 1996). They are based, in particular, on accounting for the duration of cooperation with consumers and the rate of growth of the customer base. In the balance of consumers, he suggests identifying: new clients, those who have refused service, as well as those increasing and decreasing consumption.

2.2. Methodology of mathematical modeling of the recommendation process

The process model of growth in the number of service users (Y) (Prichina, 2023) is presented in Fig. 1. Here X is the number of new users per month, H is the number of new users per month under the influence of promotion. By promotion we mean all types of paid influence on potential consumers.

On the right in Fig. 1 are the main types of consumers exiting the service center, providing free feedback on the service they used.

The following four main consumer groups are identified here (Prichina, 2023):

- They continue to receive the service and are satisfied with it (A).
- We have finished receiving the service and are satisfied with it (B).
- Not satisfied with the service, give negative feedback (C).
- Chose another service due to personal circumstances, neutral (D).

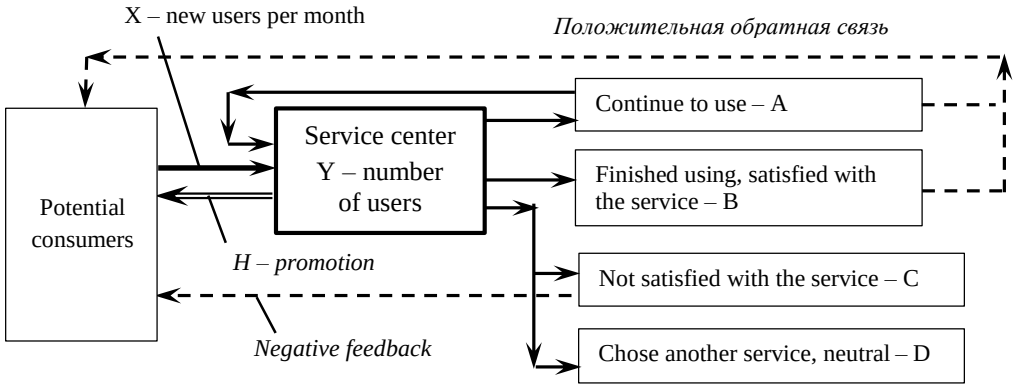

Figure 1: Process model of growth in the number of service users.

The duration of service use varies greatly in different areas of activity. In the field of Therapeutic and physical rehabilitation (TPR) of musculoskeletal disorders (MDD), this can be one monthly cycle (approximately 12 sessions) or several dozen cycles if the disease has become chronic.

TPR clinics , there are consumers who are satisfied with the service but stop using it because they have mostly recovered (group A). There are also consumers who do not have a negative impression of the service (D – neutral) (Rosen, 2013), but stop using it due to personal circumstances or as a result of switching to alternative services.

Consumers in groups B and D may be re-engaged as users in the future.

Other consumer groups could be identified, but this would complicate the model without producing significant results.

To form a digital model of the influence of outputs on inputs, we will set the coefficients of the influence of user groups on consumers of the service center and designate them: K_A, K_B, K_C, K_D, in accordance with the types of consumers at the output. Here, the number of users of type A , B , C , D , H is measured in the number of patients. The share of these patients from the number of those undergoing treatment (Y) will be designated by the corresponding lowercase letters
(a = A / Y , b = B / Y , c = C / Y , d = D / Y), where a + b + c + d = 1.

The equations describing the recommendation process in the difference representation have the following form (Prichina, 2023):

$$Y_i = A_i + B_i + C_i + D_i \quad (1)$$

$$Y_{i+1} = A_i + H + K_A A_i + K_B B_i - K_S S_i . \quad (2)$$

Equation (2) can be represented as:

$$Y_{i+1} = aY_i + H + Y_i(aK_A + bK_B - cK_C). \quad (3)$$

From now on we will call it the “Recommendation Equation” . When $Y_{i+1} \rightarrow Y_i$ from (3) it follows that

$$Y_i/H = 1/(1 - a(1 + K_A) - bK_B + cK_C).$$

Let us denote the right-hand side of the last equation by the symbol R and we will further call this expression the “recommendation parameter” (Karanashev, 2024).

$$R = 1/(1 - a(1+K_A) - bK_B + cK_C). \quad (4)$$

Accordingly, the maximum value Y_{max} will be expressed by the formula

$$Y_{max} = H R . \quad (5)$$

The recommendation parameter (R) thus summarizes the values of most of the coefficients in equation (3) that influence the flow of consumers to the service delivery center.

Calculation of the dynamics of the number of consumers Y_i was performed using Excel spreadsheets using equation (3).

3 RESULTS

The model considered in this paper is quite universal, but it will be specifically applied to the healthcare sector - to the network of TPR clinics for patients with musculoskeletal diseases (MDD). This is due to the fact that in different industries, numerous digital coefficients of the recommendation process differ quite significantly. Therefore, a holistic consideration of an abstract composition of 8 coefficients will make the work too voluminous for publication in a journal. In addition, the authors' first publication on this topic (Prichina, 2023) was carried out in relation to the healthcare sector.

To assess the proportion of clients who continue to receive treatment services (A), are fully cured (B), are dissatisfied with the service (C) or leave the center for other reasons – D , a survey of TPR clinic managers was conducted , the results of which are presented in Fig . 2.

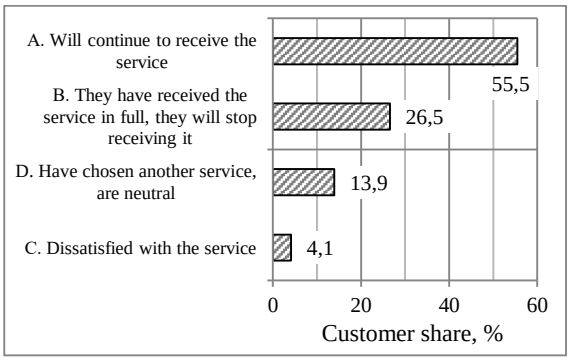

Figure 2: The composition of clients who have received a cycle of services, %.

The number of new patients admitted to the clinic per month varies from 11 in new centers to 30-50 in long-standing centers. The average number of new patients is 27 per clinic, and the number of students is about 60, with each of them attending 10-12 classes per month.

Due to the diversity of centers, the coefficients included in the recommendation parameter vary greatly. For initial calculations, we will select a model close to the average for the network of clinics. The coefficients of this model are given in Table 1.

Table 1: The values of the coefficients used.

Consumer type	A	B	C	D
Share of consumers	a	b	c	d
	0.6	0.2	0.05	0.15
Influence coefficient	K_A	K_B	K_C	K_D
	0.4	0.6	1.0	0

3.1. Calculating customer growth

An example of the growth in the number of clients in accordance with the difference equations (1) – (3) and the coefficients from Table 1 is shown in Fig . 3. Here Y is the total number of users, X is the number of new users per month, B is the number of those who stopped using the service per month, C is the number of those dissatisfied with the service.

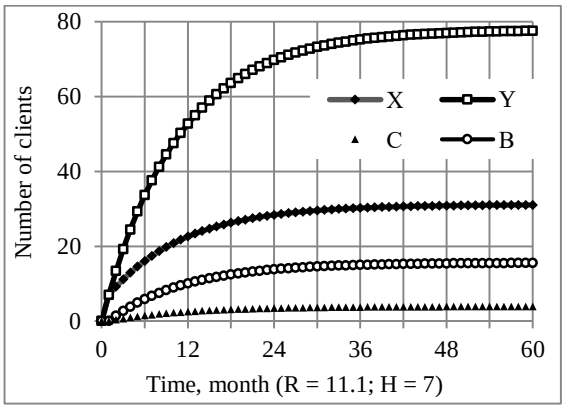

Figure 3: Customer growth.

The dynamics of the number of clients qualitatively corresponds to the growth in the number of patients observed in practice in TPR clinics (Prichina, 2023). As in Fig . 3, in practice, by the end of the third year, the number of patients reaches a conditional maximum ($Y_{i+1} / Y_i = 1.003$).

From formula (5) it is clear that the growth rate of the number of clients depends not only on the recommendation parameter, but also on the promotion activity (H). If at some point in time T_2 the value of H is reduced to the level of H_2, then according to formula (5) the number of patients will begin to asymptotically decrease to the new value RH_2.

In particular, Fig. 4 shows the dynamics of the number of clients in the case when after $T_2 = 20$ the promotion decreased from $H_1 = 7$ to $H_2 = 4$ people/month.

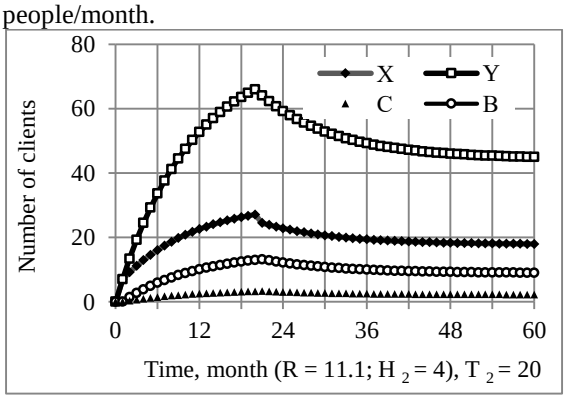

Figure 4: The growth in the number of clients with variable promotion – H.

After decreasing H to H_2, the number of clients begins to fall to the level $Y = H_2 R = 4 \cdot 11.1 = 44.4$.

In order to avoid the regime with a decreasing number of patients, it is necessary to reduce the promotion to the level H_2 at the time T_2, at which the value of $Y = H_2 R$. The step graph of the growth of the number of clients under such promotion control is shown in Fig. 5.

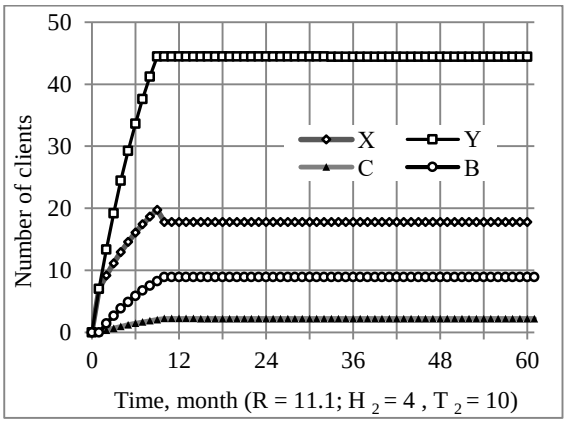

Figure 5: Stepwise change in the number of clients due to the choice of the time of decrease of H.

As can be seen from equation (4), the recommendation parameter can also take negative values. Thus, if the share of consumers of type A increases from a = 0.6 to a = 0.68 (respectively, the share of consumers of group D decreases from 0.15 to 0.07, since a + b + c + d = 1), then the coefficient R will be equal to – 45.

In this case, the dynamics of the number of clients will grow rapidly, as shown in Fig. 6.

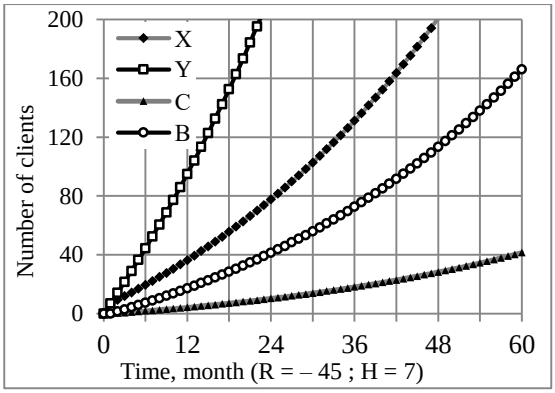

Figure 6: Growth in the number of clients at R = – 45.

If the number of clients of type A decreases from 0.6 to a = 0.5 (d = 0.25), then R = 4.3 and the maximum number of patients will decrease, and the achievement of the slow growth mode will be much faster, as shown in Fig. 7.

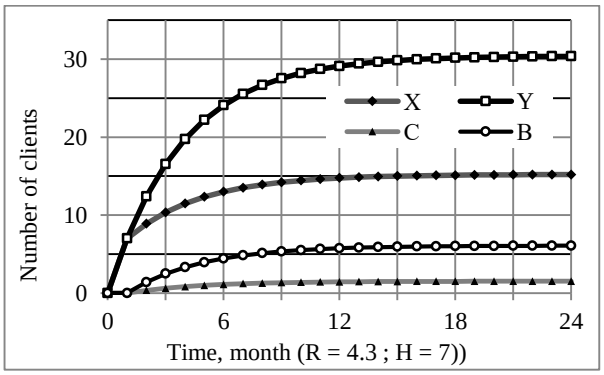

Figure 7: Increase in the number of clients with a decrease in R to 4.3.

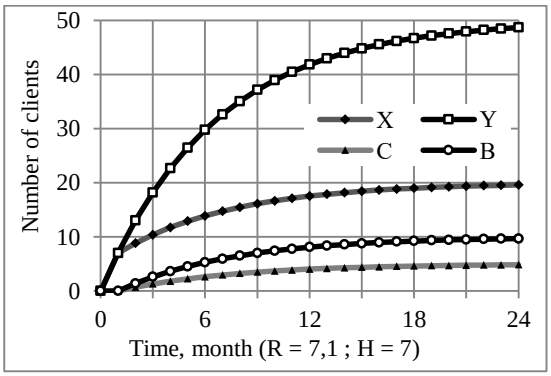

Figure 8: The impact of an increased number of negative reviews (c = 0.1).

Thus, even a relatively small change in the number of customers continuing to consume the service has a very strong impact on the recommendation parameter and the growth dynamics of the number of consumers.

If, however, with a = 0.6, the number of dissatisfied customers doubles due to neutral ones (c = 0.1, d = 0.1), then the recommendation parameter R will decrease less than when the parameter a decreases to 0.5, and it will be equal R = 7.1. The corresponding dynamics of the number of clients of the service center is given in Fig. 8 .

Thus, an increase in the number of dissatisfied customers may have a weaker effect on the growth of the center than the number of those who continue to consume the service. Thus, the advantage of the recommendation parameter as an indicator of the quality of the service is manifested. However, it should be taken into account that the coefficient of influence K_C of dissatisfied customers may be greater than in the model under consideration and it is desirable to determine it more accurately.

At the same time, it should be taken into account that reviews are transmitted individually and do not affect the entire contingent of potential consumers, as is laid down in this mathematical model. Therefore, at the beginning of the service center's work, the simultaneous influence of positive and negative reviews on the same potential consumer is unlikely.

Table 2: Patient flows influenced by recommendations

No.	Parameter	Jn	Fb	Mr	Ap	My	In	Il	Av	Sp	Ok	Nb	Dc
1	Directions	6	3	4	4	5	10	18	14	8	13	11	1
2	Advertising	3	3	1	6	2	11	7	9	6	9	9	7
3	Recommendations	81	85	111	112	93	77	94	76	80	91	79	65
4	Appeals	90	91	116	122	100	98	119	99	94	113	99	75
5	New patients	50	55	35	66	61	51	60	65	61	50	71	49
6	Conversion, %	56	60	30	54	61	52	50	66	65	44	72	65
7	Classes in the hall	922	1059	1269	1139	1239	1219	1212	1257	1184	1289	1410	1132
8	Other services	733	876	1111	1218	922	721	1268	1304	1103	926	1465	1027
9	Patients	138	161	198	196	180	162	207	213	191	185	240	180
10	R	15.3	26.8	39.6	19.6	25.7	7.6	8.3	9.3	13.6	8.4	12.0	22.5

3. 2 Patient flows according to recommendations in practice

Let us consider how patient flows change in practice under the influence of recommendations at the BRG clinic (Ramenskoye) in 2023 (Table 2). Here, lines 1–3 indicate the number of visits to the clinic per month through advertising channels, recommendations from patients of groups A and B, as well as referrals from doctors of other organizations or medical integrators. The flow by referrals, from the point of view of some marketers (Tatarinov, 2019; Rosen, 2009), is considered advisory. However, these

recommendations are partially paid for, so we will classify them as promotion - H. Together, these flows of requests lead to the appearance of new patients, some of whom go to the gym for kinesitherapy classes, while the others receive other services. To determine the total number of patients receiving treatment (Y), we divide the total number of classes in the gym and other procedures by the average number of classes per month (as a rule, patients come for procedures every other day; 3 times a week; 12 times a month).

To determine the recommendation parameter (R), we use formula (5) – we divide the number of patients (Y) by the sum of flows by directions and advertising (H). Table 2 also shows the conversion values, i.e. the ratio of the number of new patients to the number of requests.

The average value of the recommendation parameter for BRG is 13.2, which is slightly higher than in the model calculations given above. This is due to the fact that the BRG clinic has been operating for more than 7 years and has accumulated a large number of loyal patients who undergo treatment regularly.

It is evident that the recommendation parameter changes quite significantly over time. This is due to the fact that March and April are the months of the most active visits to the clinic by patients and the maximum activity of recommenders at this time. Therefore, promotion was reduced in these months, which manifested itself in an increase in the R parameter . During this period, the number of requests reaches the maximum number of patients that the clinic can accept, so the conversion decreases.

Thus, taking into account the influence of feedback allows us to evaluate the dynamics of growth in the number of patients and optimize the intensity of promotion.

4 DISCUSSION

To evaluate the coefficients a, b, c, d, presented in Table 1, a survey of center managers was used in the work. However, this method of evaluation is not sufficiently accurate.

For a more accurate assessment of the coefficients a, b, c, d, it is necessary to assess in the center under study after the end of the selected time period how many clients belong to groups A, B, C, D. Then, using statistical processing, it is possible to assess the value of the coefficients a, b, c, d. In this case, it is necessary to take into account the influence of the center's operating time and the main diseases characteristic of this center on these coefficients.

To evaluate the influence coefficients K_A and K_B, it is necessary for the center administrator to record who was the referrer (full name) for patients who came to the center on recommendation. Then it is possible to determine to which group (A and B) the referring clients belong.

It is also necessary to record how much time has passed since the recommenders received the treatment service. This will allow us to assess the duration of the influence of the recommenders on potential consumers.

The method for assessing the value of the coefficient K_D can be as follows. When calling patients of categories A and D who have not visited the clinic for a long time , it is necessary to record the client's full name and, using the database, determine the period of time that has passed since his last visit to the center, the patient's category (A or D), the disease group, and the level of competition in the environment of a specific center. When accumulating statistical data, an analysis can be carried out that allows assessing the dependence of the coefficient K_D on various characteristics.

In the future, it is planned to conduct research to improve the methodology for determining the coefficients presented in Table 1.

5 CONCLUSIONS

1. The maximum number of clients of service centers is directly proportional to the promotion activity (H) and the recommendation parameter (R), which in general terms characterizes the flow of consumer recommendations and the duration of their use of the service.

2. The average duration of use of their service has a strong influence on the growth of the number of clients. At the same time, negative reviews may have less influence on the growth of the number of clients.

3. Management of the promotion mode, as calculations have shown, allows for rapid growth in the number of clients to the required level, and then the transition to an economical promotion mode without the stage of reducing the number of patients.

4. The conducted research of the dynamics of the recommendation parameter in relation to the clinic of medical and physical rehabilitation of the musculoskeletal system show that its value during the year changes from 7.6 to 39.6, and on average is 13.2. Thus, customer recommendations increase the flow

of patients more than 10 times compared to that generated by promotion.

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