ORDER OPTIMIZATION OF HEALTH RESORTS TREATMENT USING PALMER'S ALGORITHM AS ONE OF THE KEY ACTIVITIES DESCRIBING THE BUSINESS MODEL

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Abstract: The aim of the article is to present one of the optimization methods of logistics processes, as solutions to improve operational efficiency in business models of spa enterprises. The author uses the Palmer's algorithm, using it to optimize the schedule of performing treatments in health resorts. The final result of the publication is the proposal to use the Palmer's algorithm with the author's amendment. The solution was supported by an example of using its for health resort treatments.

Keywords: optimisation, Palmer's algorithm, health resorts, business model.

1. Introduction

Modern business models serve to describe the premises behind the way in which the organization creates value and provides and derives profits from this created value. A. Osterwalder and Z. Pigneur (2010) list nine elements describing the business model. Among them are key activities that are designed to create and present to the client a proposal for value, maintain relationships with customers and generate revenues. The issue of proper organization of physiotherapy treatments may be a significant activity of improving operational efficiency and relations with direct clients, and at the same time providing value to clients.

Until now, the actions taken by the physiotherapy institute managers have come down to a situational approach, i.e. solving a specific problem, depending on the existing situation. The limited ability to simultaneously take into account several and sometimes dozens of initial conditions makes the problem complex and the solution obtained was often disappointing and certainly was not and is not optimal. Imperfection in the planning of treatments was often the reason for disorganization and confusion, which concerned not only patients but also those performing treatments.

Patient receiving a schedule of his treatments often learned from him that one of his treatments falls out at the time of breakfast or dinner, or that the time of ending one of the treatments is also the time of starting another surgery in another facility. In extreme cases, in spas, where treatments are performed in several objects, there was also a situation of overlapping times of two treatments of one patient (Rzeczyński, 2001).

However, the employees of natural medicine institutions wanting to implement the ordered treatments, had to cope with the dissatisfaction of the queued patients, and at the same time perform the treatments carefully and with all the procedures. Difficulties in the implementation of treatment schedules often had their consequences in the form of employee dissatisfaction, who remained after hours to implement all the treatments ordered. This was often the reason for conflicts with employers, which also reflected the quality of the business and the satisfaction of the patients.

The efficiency and effectiveness of the conducted physiotherapy activities largely depended on the manager's ability to logically plan the received orders, and along with the development of IT – to the ability to use the scheduling tools. Nowadays an increasing use of IT tools in operational management of spa facilities is observed. Nevertheless, the knowledge of IT tools is insufficient without knowledge of methods for optimizing operations.

The aim of the article is to present one of the methods of optimization of logistics processes. The author uses the Palmer algorithm, using it to optimize the schedule of performing treatments in health resorts. The final result of the publication is the proposal to use the Palmer algorithm with the author's amendment. The solution was supported by an example of the order of natural therapies.

2. Spa activities conducted as part of health resorts tourism

Tourist activity, through which the health goal is implemented, is referred to as health tourism. Although it is not a full definition, it reveals the basic purpose of undertaking this type of activity by a human being. However, this goal can be implemented in various ways, hence the distribution of forms of health tourism found in the literature on the subject (Januszewska et al., 2010):

- medical tourism, meaning trips to receive medical help,
- dental tourism, i.e. trips to treat teeth,
- spa & wellness tourism, thus determining stay oriented towards optimal health and wellness, in which there is integration of physical, mental and spiritual spheres to achieve fulfillment in the natural and social environment (Myers et al., 2011),
- rehabilitation tourism, undertaken for undertaking rehabilitation therapy,
- spa tourism (health resorts tourism) – preventive and curative stays in spas
- using local natural resources.

The most popular form of health tourism is spa tourism with the necessary spa treatment. It does not affect the human body in a direct way, e.g. through pharmacotherapy or invasive techniques (as is the case in medical or dental tourism), but through natural forms of influence (climate, water, natural materials) leads to better health, maintaining the effects of therapy much longer than in the case of other forms of health tourism.

The difference between health and spa tourism lies mainly in specifying (in the case of spa tourism) places of rest and methods of recreation. Health tourism, unlike spa health, does not have to be carried out in a health resort. Thus, the phenomenon of spa tourism is a key (but still only) element of a wider phenomenon, which is the phenomenon of health tourism. Therefore, the term spa tourism results from the specialization of the term health tourism. In this respect, a scheme created by a team of Polish researchers – M. Januszewska, E. Nawrocka and S. Oparka (Januszewska et al., 2010) seems to be interesting, which synthesize features related to health and spa tourism, as well as the location of health tourism in health tourism (fig. 1).

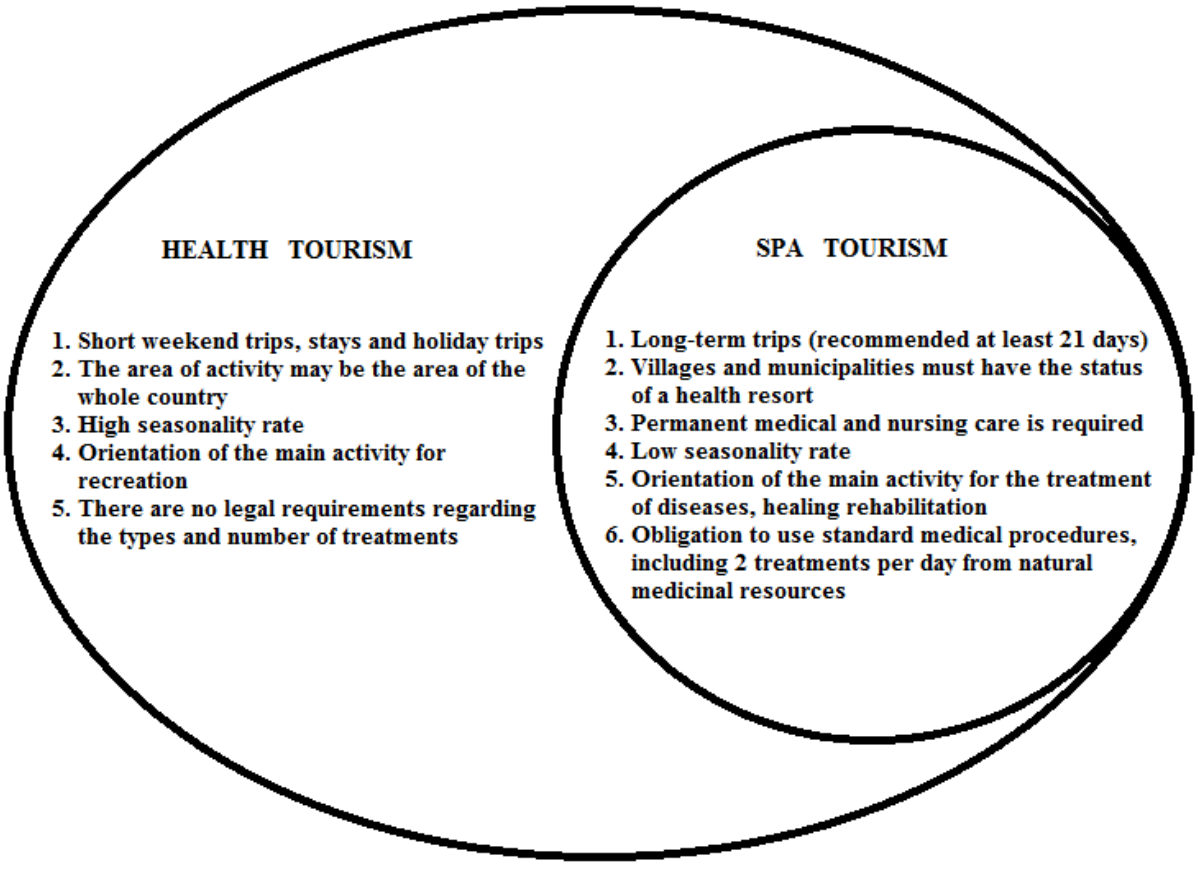

Figure 1. Basic differences in meaning between health and spa tourism. Adapted from: Januszewska et al., 2010.

3. Optimization of the order of physiotherapy and operational activities of the plant

The solution to the problem of the optimal order of execution of orders (production scheduling) depends on the adoption of certain conditions. One of the key conditions for selecting the appropriate algorithm is the number of different positions on which orders are executed. The simplest case is the situation in which there is only one type of workstation and it does not matter to which of them the order will go. The situation changes when we take into account the jobs of various types through which the order should pass.

S. Krawczyk reminds that tasks carried out in various positions can be divided into three types (Krawczyk, 2001a):

a) an open-shop system, in which the sequence of operations (orders on one site) is free,
b) a flow-shop in which every facility must pass through all positions in a predetermined order (the order in which each operation is performed under a certain order is obligatory),
c) a general job-shop system in which a specific order for the order of operations on positions has been established for each order, but different orders may have different order.

Literature cites many possible methods of optimization. This paper focuses on the scientific work of researchers in the field of optimization, forecasting and simulation methods as well as quantitative methods in logistics (including S. Krawczyk (2001a, 2001b), K. Kukuła et al. (2000), J.B. Gajda (2001)). In terms of optimizing the services provided, it was based on the work of B. Rzeczyński (2001).

In the situation when each bather received at least 3 treatments ($m \geq 3$), it is necessary to use a complex algorithm that takes into account the order of orders, eg the Palmer algorithm (Palmer, 1965). It is used to optimize the order of orders, under which operations have a strictly determined order of their implementation. Therefore, the logistic problem involved requires the assumption that we are dealing with orders ($A_1, A_2, A_3, ..., A_n$), on which a specific set of operations is performed on several differentiated surgical stations ($S_1, S_2, S_3, ... S_m$) in the set order. Also known are the times of performing individual operations ($t_1, t_2, t_3, ..., t_n$) and a set of weights for positions ($w_1, w_2, w_3, ..., w_m$), which were selected in accordance with the following procedure:

- we assign the weight to the first position [- $(m-1)$],
- assign the balance to the second position [- $(m-1) +2$],
- we increase the weights of subsequent posts by 2,
- position m receives weight ($m-1$).

The product of weights and operation times of subsequent orders allows to determine the sequence index k_i, which is also the basis for ordering orders (see Fig. 2).

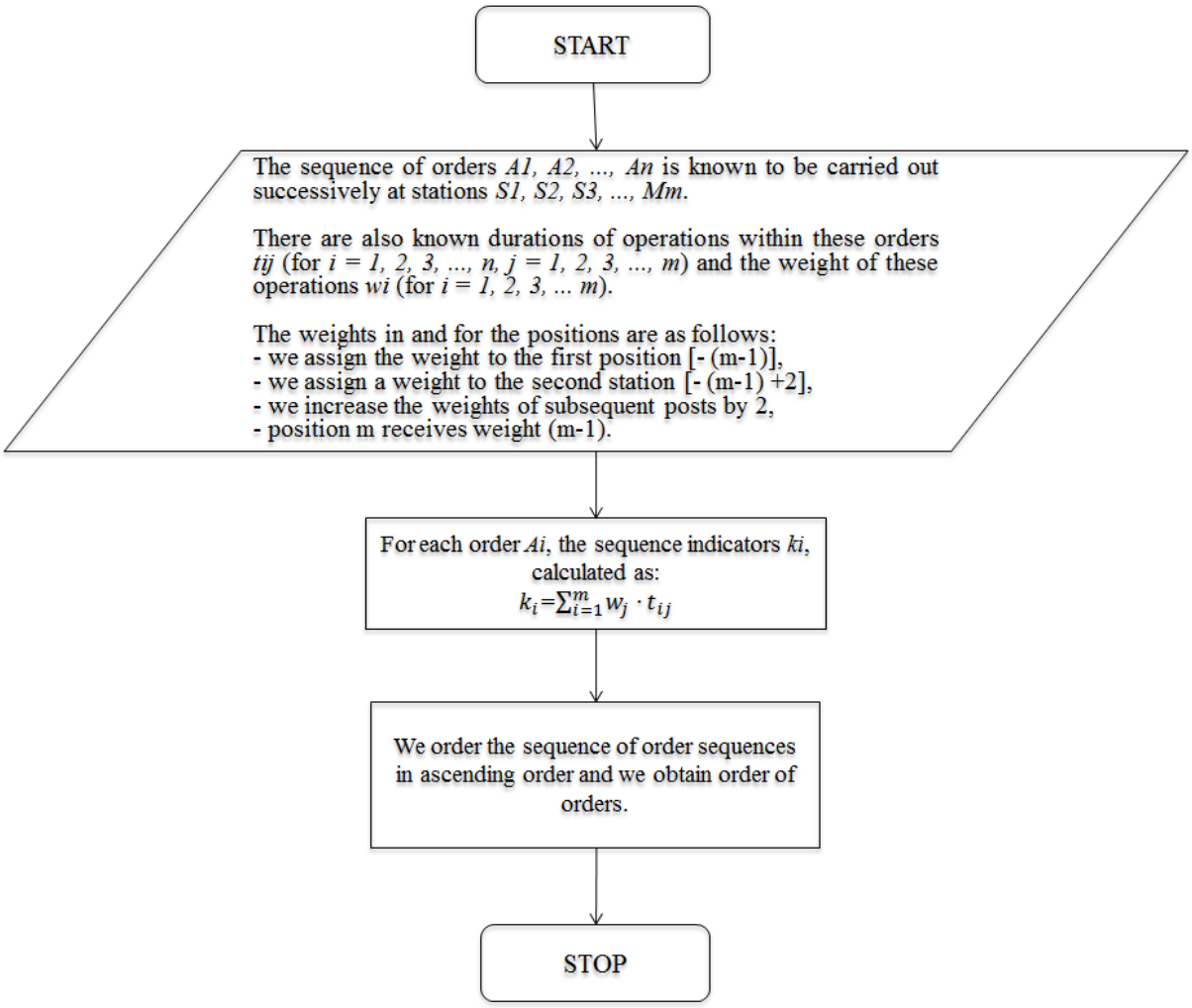

Figure 2. Palmer algorithm scheme. Adapted from: Own study based on Krawczyk, 2001.

The practice of using the Palmer algorithm proves that it is a useful and effective tool for determining the order in which orders are executed in a situation where the times of operations are not very different from each other. However, if the times of one or several orders are significantly different from the times of other orders, the Palmer algorithm with a correction gives a much better effect of organizing the order of order execution. The introduced correction consists in averaging the sum of operation times of individual orders and determining their relation to the average time. The ratio of total to average time of orders exceeding the value of 1.0 indicates the need to increase the order index by twice the average, then these orders are moved to the end of the order (fig. 3).

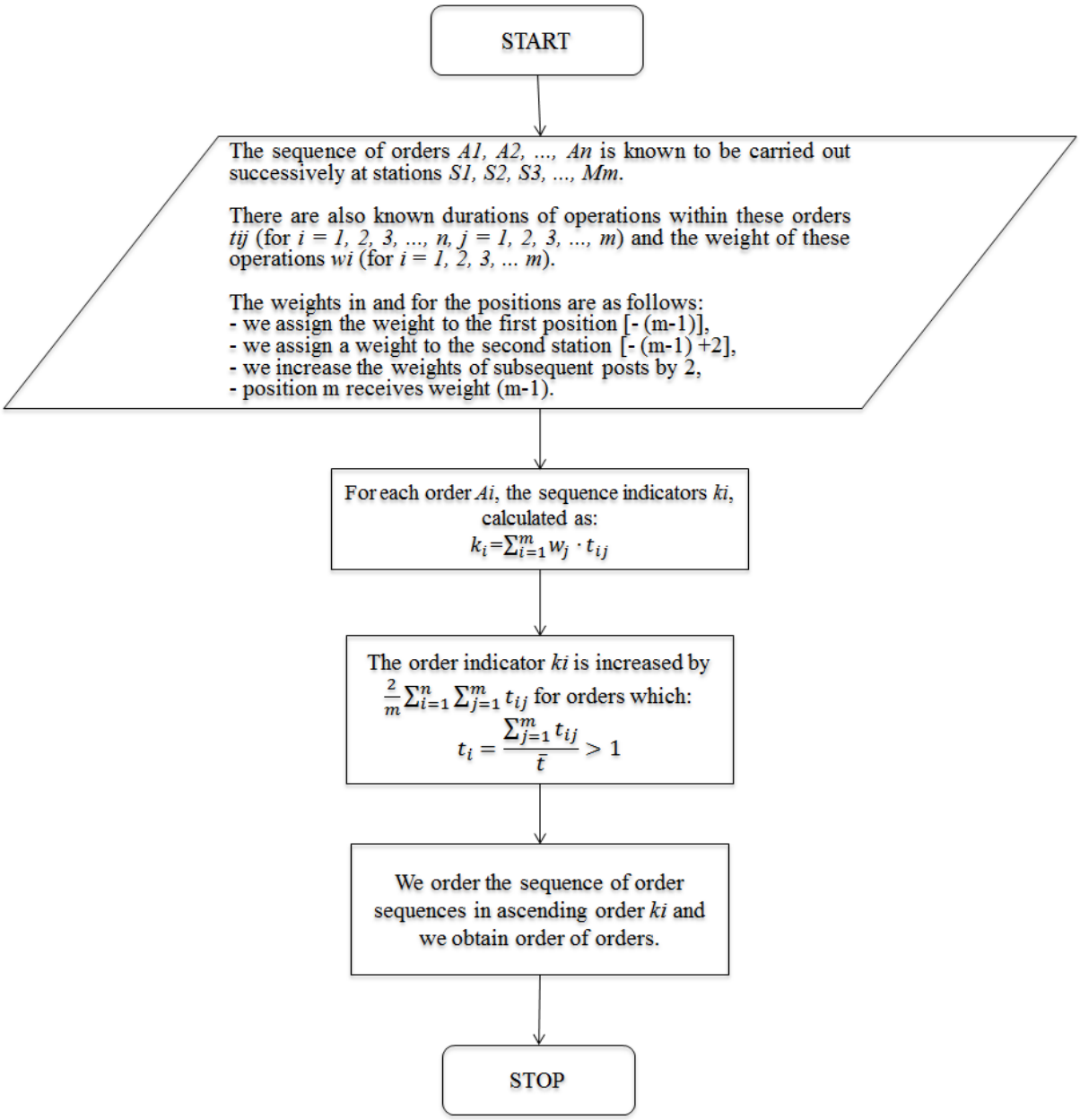

Figure 3. Diagram of Palmer algorithm with the modification of Szromek Adapted from: Own study based on Szromek, 2017.

4. Exemplification of the use of the Palmer algorithm with modification

In order to explain the transformations made, it is worth considering the theoretical problem of the sequence of operations requiring the adoption of the right order. In the gymnasium there are 7 gymnastic stands (*S1, S2, S3, ..., S7*). They were set in such a way as to start with a warm-up and finish with stretching the muscles. This means that the patient subject to the rehabilitation program passes through each of the posts in a specific order, taking advantage of the breaks between the rest positions in the salt cave. Plan a rehabilitation

session for 10 patients (*A1, A2, A3, ..., A10*) at all positions, determining the order of their arrival and minimizing the waiting time for the next part of the program. Take into account the fact that each patient has an individual exercise time at each position (in minutes), and the rehabilitation facility works from 8:00 to 16:00.

Table 1.
Delivery times for 7 positions

Orders	S1	S2	S3	S4	S5	S6	S7
A1	17	6	7	11	14	4	4
A2	8	5	9	14	14	7	5
A3	17	13	22	25	20	13	15
A4	18	20	22	26	17	16	12
A5	28	37	41	43	35	32	26
A6	23	20	18	23	18	16	14
A7	44	52	57	45	43	36	40
A8	17	20	19	18	16	14	13
A9	25	22	30	20	19	24	15
A10	18	21	23	19	17	15	13

Source: Author's own study.

In accordance with the method of weighing the stands, the weighing system was established, and then the order indicators k_i were calculated.

Table 2.
Delivery times for 7 positions with weights

Orders	S1	S2	S3	S4	S5	S6	S7
weight:	w_1	w_2	w_3	w_4	w_5	w_6	w_7
	-6	-4	-2	0	2	4	6
A1	17	6	7	11	14	4	4
A2	8	5	9	14	14	7	5
A3	17	13	22	25	20	13	15
A4	18	20	22	26	17	16	12
A5	28	37	41	43	35	32	26
A6	23	20	18	23	18	16	14
A7	44	52	57	45	43	36	40
A8	17	20	19	18	16	14	13
A9	25	22	30	20	19	24	15
A10	18	21	23	19	17	15	13

Source: Author's own study.

Table 3.
Indicators of orders in the order algorithm Palmer

Orders	S1	S2	S3	S4	S5	S6	S7	k_i
weight:	w1	w2	w3	w4	w5	w6	w7	
	-6	-4	-2	0	2	4	6	
A1	-102,0	-24,0	-14,0	0,0	28,0	16,0	24,0	-72,0
A2	-48,0	-20,0	-18,0	0,0	28,0	28,0	30,0	0,0
A3	-102,0	-52,0	-44,0	0,0	40,0	52,0	90,0	-16,0
A4	-108,0	-80,0	-44,0	0,0	34,0	64,0	72,0	-62,0
A5	-168,0	-148,0	-82,0	0,0	70,0	128,0	156,0	-44,0
A6	-138,0	-80,0	-36,0	0,0	36,0	64,0	84,0	-70,0
A7	-264,0	-208,0	-114,0	0,0	86,0	144,0	240,0	-116,0

cont. table 3

A8	-102,0	-80,0	-38,0	0,0	32,0	56,0	78,0	-54,0
A9	-150,0	-88,0	-60,0	0,0	38,0	96,0	90,0	-74,0
A10	-108,0	-84,0	-46,0	0,0	34,0	60,0	78,0	-66,0

Source: Author's own study.

According to the basis for ordering received, it was determined that they should be performed in the order of: A7, A9, A1, A6, A10, A4, A8, A5, A3, A2. The schedule for the execution of orders is presented in table 4. The patient A7 will be the longest in the service system – 5 hours and 11 minutes, and the shortest patient A2 – 3 hours and 12 minutes. The calculations showed that the intervals between the positions are significant and reach 59 minutes.

It can be seen that the second order does not start with the completion of the first order in the first position at 8:44, but at 9:11. Similarly for other orders. The shift results from the lack of necessity to start the procedure at 8:44, since with the end of it the patient would have to wait 27 minutes for the procedure performed at the next position. Therefore, the treatments performed on the first post were moved by the time of the necessary break, which eliminates the expectation of the patients between the first and second positions.

It should also be noted that the algorithm was created to reduce downtime, not to shorten the waiting time for the operation. Thus, unfortunately, some patients, having a total rehabilitation time of 1 hour and 3 minutes, spend 3 hours and 55 minutes in the room due to long queues. Thus, in two cases (A1 and A2) the waiting time for the execution of the order is longer than the order itself.

Table 4.
The schedule of execution of orders on 7 positions in accordance with the Palmer algorithm

Schedule of order fulfillment						
Orders	**S1**		**Waiting for the patient**	**S2**		**Waiting for the patient**
A7	8:00	8:44	0:00	8:44	9:36	0:00
A9	9:11	9:36	0:00	9:36	9:58	0:35
A1	9:41	9:58	0:00	9:58	10:04	0:59
A6	9:58	10:21	0:00	10:21	10:41	0:29
A10	10:23	10:41	0:00	10:41	11:02	0:26
A4	10:44	11:02	0:00	11:02	11:22	0:29
A8	11:05	11:22	0:00	11:22	11:42	0:31
A5	11:22	11:50	0:00	11:50	12:27	0:05
A3	12:10	12:27	0:00	12:27	12:40	0:33
A2	12:32	12:40	0:00	12:40	12:45	0:50
Orders	**S3**		**Waiting for the patient**	**S4**		**Waiting for the patient**
A7	9:36	10:33	0:00	10:33	11:18	0:00
A9	10:33	11:03	0:15	11:18	11:38	0:23
A1	11:03	11:10	0:28	11:38	11:49	0:31
A6	11:10	11:28	0:21	11:49	12:12	0:22
A10	11:28	11:51	0:21	12:12	12:31	0:21
A4	11:51	12:13	0:18	12:31	12:57	0:12
A8	12:13	12:32	0:25	12:57	13:15	0:11

cont. table 4

A5	12:32	13:13	0:02	13:15	13:58	0:00
A3	13:13	13:35	0:23	13:58	14:23	0:10
A2	13:35	13:44	0:39	14:23	14:37	0:16
Orders	**S5**		**Waiting for the patient**	**S6**		**Waiting for the patient**
A7	11:18	12:01	0:00	12:01	12:37	0:00
A9	12:01	12:20	0:17	12:37	13:01	0:16
A1	12:20	12:34	0:27	13:01	13:05	0:27
A6	12:34	12:52	0:13	13:05	13:21	0:15
A10	12:52	13:09	0:12	13:21	13:36	0:14
A4	13:09	13:26	0:10	13:36	13:52	0:11
A8	13:26	13:42	0:10	13:52	14:06	0:09
A5	13:58	14:33	0:00	14:33	15:05	0:00
A3	14:33	14:53	0:12	15:05	15:18	0:13
A2	14:53	15:07	0:11	15:18	15:25	0:21
Orders	**S6**		**Total time in the gym**			
A7	12:37	13:17	5:17			
A9	13:17	13:32	4:21			
A1	13:32	13:36	3:55			
A6	13:36	13:50	3:52			
A10	13:50	14:03	3:40			
A4	14:03	14:15	3:31			
A8	14:15	14:28	3:23			
A5	15:05	15:31	4:09			
A3	15:31	15:46	3:36			
A2	15:46	15:51	3:19			

Source: Author's own study.

It is worth considering using the Palmer algorithm with the patch and compare the solutions. Then the schedule of orders implementation is presented in Table 5.

Table 5.
The schedule of execution of orders on 7 positions in accordance with the Palmer algorithm

Schedule of order fulfillment						
Orders	**S1**		**Waiting for the patient**	**S2**		**Waiting for the patient**
A1	8:00	8:17	0:00	8:17	8:23	0:00
A6	8:17	8:40	0:00	8:40	9:00	0:00
A10	8:42	9:00	0:00	9:00	9:21	0:00
A4	9:03	9:21	0:00	9:21	9:41	0:03
A9	9:21	9:46	0:00	9:46	10:08	0:00
A8	9:51	10:08	0:00	10:08	10:28	0:01
A3	10:11	10:28	0:00	10:28	10:41	0:07
A2	10:33	10:41	0:00	10:41	10:46	0:24
A7	10:41	11:25	0:00	11:25	12:17	0:00
A5	11:49	12:17	0:00	12:17	12:54	0:20
Orders	**S3**		**Waiting for the patient**	**S4**		**Waiting for the patient**
A1	8:23	8:30	0:00	8:30	8:41	0:00
A6	9:00	9:18	0:00	9:18	9:41	0:00
A10	9:21	9:44	0:00	9:44	10:03	0:00
A4	9:44	10:06	0:00	10:06	10:32	0:00
A9	10:08	10:29	0:03	10:32	10:52	0:00
A8	10:29	10:48	0:04	10:52	11:10	0:01
A3	10:48	11:10	0:00	11:10	11:35	0:00

cont. table 5

A2	11:10	11:19	0:16	11:35	11:49	0:06
A7	12:17	13:14	0:00	13:14	13:59	0:00
A5	13:14	13:55	0:04	13:59	14:42	0:00
Orders	**S5**		**Waiting for the patient**	**S6**		**Waiting for the patient**
A1	8:41	8:55	0:00	8:55	8:59	0:00
A6	9:41	9:59	0:00	9:59	10:15	0:00
A10	10:03	10:20	0:00	10:20	10:35	0:00
A4	10:32	10:49	0:00	10:49	11:05	0:00
A9	10:52	11:11	0:00	11:11	11:35	0:00
A8	11:11	11:27	0:08	11:35	11:49	0:01
A3	11:35	11:55	0:00	11:55	12:08	0:00
A2	11:55	12:09	0:00	12:09	12:16	0:07
A7	13:59	14:42	0:00	14:42	15:18	0:00
A5	14:42	15:17	0:01	15:18	15:50	0:08
Orders	**S6**		**Total time in the gym**			
A1	8:59	9:03	1:03			
A6	10:15	10:29	2:12			
A10	10:35	10:48	2:06			
A4	11:05	11:17	2:14			
A9	11:35	11:50	2:29			
A8	11:50	12:03	2:12			
A3	12:08	12:23	2:12			
A2	12:23	12:28	1:55			
A7	15:18	15:58	5:17			
A5	15:58	16:24	4:35			

Source: Author's own study.

The obtained results are much better than before, because the waiting time for the execution of the order in no case exceeds the time of order execution, and the longest waiting time for surgery decreased to 24 minutes. The total queue time only in two cases (A2 and A5) exceeded 15 minutes. The optimal order of execution of orders is: A1, A6, A10, A4, A9, A8, A3, A2, A7, A5.

5. Conclusions

Scheduling natural therapies is one of the complex processes of the organization of spa services, and at the same time is an important activity supporting the operational efficiency of the business model. The use of spreadsheets and computer programs greatly facilitates this process, however, due to the high degree of individualization of problems, the above algorithm should be treated as a starting point in the process of optimizing the scheduling processes.

It is worth noting that the introduction of an amendment to the already existing algorithm has improved the efficiency of treatments, which at the same time affects the opinion of patients. Thus even small facilities can support the spa resort manager in building

a competitive advantage and increasing value for the client. Improving opinions on customer service is certainly one of the key factors in improving the business model of spa enterprises.

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