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Dear Esteemed Readers, Authors, and Colleagues,

I hope this letter finds you in good health and high spirits. It is my distinct pleasure to address you as the Editor-in-Chief of Integrative Omics and Applied Biotechnology (IIOAB) Journal, a multidisciplinary scientific journal that has always placed a profound emphasis on nurturing the involvement of young scientists and championing the significance of an interdisciplinary approach.

At Integrative Omics and Applied Biotechnology (IIOAB) Journal, we firmly believe in the transformative power of science and innovation, and we recognize that it is the vigor and enthusiasm of young minds that often drive the most groundbreaking discoveries. We actively encourage students, early-career researchers, and scientists to submit their work and engage in meaningful discourse within the pages of our journal. We take pride in providing a platform for these emerging researchers to share their novel ideas and findings with the broader scientific community.

In today's rapidly evolving scientific landscape, it is increasingly evident that the challenges we face require a collaborative and interdisciplinary approach. The most complex problems demand a diverse set of perspectives and expertise. Integrative Omics and Applied Biotechnology (IIOAB) Journal has consistently promoted and celebrated this multidisciplinary ethos. We believe that by crossing traditional disciplinary boundaries, we can unlock new avenues for discovery, innovation, and progress. This philosophy has been at the heart of our journal's mission, and we remain dedicated to publishing research that exemplifies the power of interdisciplinary collaboration.

Our journal continues to serve as a hub for knowledge exchange, providing a platform for researchers from various fields to come together and share their insights, experiences, and research outcomes. The collaborative spirit within our community is truly inspiring, and I am immensely proud of the role that IIOAB journal plays in fostering such partnerships.

As we move forward, I encourage each and every one of you to continue supporting our mission. Whether you are a seasoned researcher, a young scientist embarking on your career, or a reader with a thirst for knowledge, your involvement in our journal is invaluable. By working together and embracing interdisciplinary perspectives, we can address the most pressing challenges facing humanity, from climate change and public health to technological advancements and social issues.

I would like to extend my gratitude to our authors, reviewers, editorial board members, and readers for their unwavering support. Your dedication is what makes IIOAB Journal the thriving scientific community it is today. Together, we will continue to explore the frontiers of knowledge and pioneer new approaches to solving the world's most complex problems.

Thank you for being a part of our journey, and for your commitment to advancing science through the pages of IIOAB Journal.

Yours sincerely,

Vasco Azevedo

Vasco Azevedo, Editor-in-Chief
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ARTICLE

A MATHEMATICAL PROGRAMMING APPROACH TO PAIRED KIDNEY EXCHANGE: THE CASE OF TURKEY

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ABSTRACT

Background: *Kidney exchange has become a very common and important treatment alternative for patients suffering from serious kidney diseases with incompatible donors. Factors such as blood type, HLA matches and PRA existence are considered to determine compatibility. In a paired exchange, two incompatible patient-donor pairs switch their donors who are compatible with the other recipient. Currently, each hospital in Turkey operates individually in a decentralized manner using its own list. This list may contain patients having more than one incompatible donor, which differentiates the current work from those existing in literature.* ***Methods:*** *In this study, mathematical models are developed to propose an easy and practical approach for the paired kidney exchange problem in Turkey. Data are generated by employing a real data set provided by a hospital specialized in kidney transplantation.* ***Results:*** *The optimal solutions are obtained by using GAMS/CPLEX, and different scenario analyses are performed to measure the impact of "gender differences" and "age" on the solution. Furthermore, the original patient-donor list provided by the hospital is used to compare the model's solution with the planned transplantations. The study also evaluates a centralized approach which integrates all hospitals performing paired kidney exchange in Istanbul.* ***Conclusions:*** *As the optimal solution of the model is obtained in a basis of seconds, the developed approach offers an easy and applicable procedure for paired kidney exchange. Comparison of decentralized and centralized approaches reveals that the centralized approach is more favorable in terms of HLA compatibility and number of transplantations.*

KEY WORDS
OR in health services, paired kidney exchange, living donor, mathematical modelling

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INTRODUCTION

Organ transplantation is the process of replacing a failing organ with a healthy one from another person or from a different part of the patient's body. Nowadays, most of the organs, such as; kidney, liver, heart, pancreas, lung and small intestine can be transplanted from donors to patients who are suffering from organ failure throughout the world.

Healthy organs can be obtained from either deceased or living donors. According to relevant literature [1], the insufficient number of cadaveric organ donations is leading to an increase in organ transplants from living donors. In 1933, the first successful kidney transplant was performed from cadaver by the Ukrainian Professor Yurii Woronoy, MD, whose patient died 48 hours after the operation due to shortages in technical equipment and limited knowledge on transplantation. The first successful kidney transplantation from a living donor was carried out in 1954 in Boston, USA, and was more successful than the previous one. After 1950s, kidney transplantation has become a more popular treatment for the patients around the world. In Turkey, the first successful kidney transplant was performed from a mother to her son on October 3, 1975 by Professor Mehmet Haberal, MD, and his team. In 1978, the same team accomplished the first cadaver transplantation in Turkey using a cadaver that was brought from abroad via "Eurotransplant".

In paired kidney exchange, two incompatible patient-donor pairs exchange their donors who are compatible with the other recipient. During this process, important factors such as blood type, HLA (Human Leukocyte Antigens) matches, gender, age, and PRA (Panel Reactive Antibody) existence are considered to determine the compatibility, and these factors may cause some difficulties in finding compatible kidneys especially if two-way swaps is used. HLA is a parameter used to measure the tissue compatibility of pairs whereas PRA shows the immunological status of a patient awaiting organ transplantation. The main goal of paired kidney exchange is to determine the optimal coupling between volunteering living donors and potential recipients who are on the transplant waiting list. Optimal coupling refers to the high HLA compatibility between patients and donors.

In this study, a mathematical model is developed for the paired kidney exchange problem in Turkey. Moreover, the effects of gender and age on transplantation results are discussed. Some donor-patient matches are considered as undesirable by receivers, due to gender and age differences. For example; a patient-donor pair having a young donor may not accept the kidney from a pair with an older donor, as the younger donor's kidney is more preferable. Another unwanted situation may arise from gender differences, and consequently, a male donor's patient may not want to receive the organ of the other pair's female donor.

There are 22,436 patients suffering from kidney failure in Turkey who are registered in the central waiting list of cadaver kidney transplantation, and unfortunately this number is increasing each year. The total number of kidney transplantations between years 2011-2017 in terms of living and deceased donors are displayed in [Table 1]. The motivation of the current study is based on this fact, and aims to propose an improvement in the kidney transplantation system.

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Table 1: The total number of kidney transplants performed (retrieved from T.R. Ministry of Health, 8 December 2017) [2]

Year	Number of Transplantations		The Total Number of Transplantations Performed
	Living Donor	Deceased Donor	
2017	2476	659	3135
2016	2639	784	3423
2015	2534	670	3204
2014	2299	626	2925
2013	2361	585	2946
2012	2384	525	2909
2011	2435	517	2952
Total	17,128	4366	21,494

Literature review

Roth, Sönmez and Ünver [3, 4] contributed the related literature with two significant articles. They recommended mechanisms to organize kidney transplantation in a Pareto-efficient and dominant strategy encouragement-compatible manner under several restrictions on swap sizes and preferences of the receivers for a static receiver population. Same scholars showed that the increasing number of non-directed donors would lead to a relaxation in synchronicity restriction [5, 6]. Particularly, since a chain is initiated by an altruistic donor, a patient-donor pair does not have to donate a kidney before they receive one. Hence, longer chains can be organized non-simultaneously without the need for integration of high number of operating rooms and surgical teams. After the publication of the work by Rees et al. [7] in which leading ten exchanges have been submitted from the initial non-simultaneous chains, an expanding number of long non-simultaneous chains have been performed. Gentry and Segev [8] and Ashlagi et al. [9] have argued whether long chains enhance effectiveness beyond simultaneous small cycles or not. One of the significant causes is that, long chains could not raise performance if they simply acquired exchanges that could otherwise have been obtained in various shorter loops [1, 8, 10, 11, 12].

Another article by Ünver [13] demonstrated how swap exchanges should be managed through a centralized mechanism in a dynamically developing agent pool with time and compliance based preferences. They proposed dynamically efficient two-way and multi-way swap procedures that maximize total discounted swap. In recent years, various living donor kidney exchange programs have been developed to help incompatible donors of end-stage kidney disease patients. Since kidney swap models can be considered as a special case of the general assignment problem, the progress in this area can be applied to the kidney exchange model as well.

Roth et al. [3] recommended mathematical models for two-way and multi-way kidney exchange problems. By performing simulation methodology, they analyzed the effect of different exchange strategies on the number of assignments for various population sizes. The researchers concluded that the four-way exchange displays the most effective strategy. A similar conclusion is obtained both in the work by Ünver [13] who uses dynamic programming, and in the studies conducted by Ashlagi et al. [9].

Saidman et al. [14] also studied the multi-way kidney transplantation problem. The purpose of their work was to develop living donor kidney transplantation by finding compatible donor and patient pairs. A simulation based on the *Organ Procurement and Transplantation Network and Scientific Registry of Transplant Recipients (OPTN/SRTR)* data was used to appreciate the practical significance of multiple exchange combination. The results of this study demonstrated that, if three-way swaps are allowed, number of potential exchanges will increase independent of the current patient list.

The paper by Standford et al. [15] tested the policies on a simulator. This study first shows that ABO identical transplantation cannot achieve equity between different blood groups. Then, it presents a model for restricted cross-transplantation which indicates how comparable waiting times for all blood types could be achieved.

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Constantino et al. [16] evaluated kidney allocation problem by proposing distinct integer-programming formulations and showing the differences between existing models in literature. They concluded that, the developed compact formulations are computationally more preferable for large problem sizes.

More recently, Anderson et al. [17] described a long-term optimization approach that supports the *Alliance for Paired Donation (APD)* works. They also explained how a team of physicians and operations researchers worked to overcome the scepticism and resistance of the medical community to the non-simultaneous extended altruistic donor innovation.

In all of the studies mentioned above, the authors designed solutions to the living donor kidney transplantation problem. These papers emphasized the significance of kidney exchange by the help of some simulation and optimization based approaches.

As the living donor kidney allocation regulations are varying for each country, problems having different characteristics and restrictions are observed in distinct countries. So far, to the best of our knowledge, Turkey's living donor kidney allocation problem with its special factors such as; HLA score, age effect, gender differences, and existence multiple donors for a patient, has not been previously addressed through optimization models. Due to Turkey's different customs, the application of altruistic donors to hospitals is not common behavior. With all these characteristics, it is worthwhile to note that, living donor kidney exchange problem existing in Turkey has many differences from the current problems studied in literature. The next subsection explains these differences in detail.

Paired kidney exchange in Turkey

In Turkey, organ transplantation assignments are performed by the *National Organ and Tissue Transplantation Coordination System* which is called "Ulusal Organ ve Doku Nakli Koordinasyon Sistemi (UKS)". This system collects all data from the database established by the Ministry of Health, and contains data regarding all organ and tissue donations, transplantations records, receiver and donor information in the country. Hospitals registered in the system, and the Regional Coordination Centers have to input the donor and patient data to this database. Currently, there are 9 Regional Coordination Centers and 69 kidney transplantation centers in Turkey. It should be noted that, UKS manages deceased donor kidney transplantations in a centralized manner. On the other hand, living donor kidney transplantations are performed individually by hospitals in a decentralized way, that is, paired exchanges are planned by only considering the hospital's own list.

Turkey holds a good position in terms of transplants from living donors as a result of close family relations. However unlike USA and some European countries, these exchanges are managed through a decentralized system. Additionally, it is possible to observe multi-donor situations for a patient in Turkey. There are even cases where a patient joins the exchange with five donors which increases her/his transplantation possibility. Florence Nightingale Hospital and Memorial Hospital, both located in Istanbul, are two of the centers which perform living donor kidney exchange operations. However, this process is managed manually without using any software. Kidney transplant operation is a highly successful method resulting in a longer and healthier life for a patient with kidney failure. In Turkey, the number of patients whose treatment is only possible through a kidney transplant is increasing every year which emphasizes the importance of living donor kidney transplantation.

This study aims to solve the living donor kidney transplantation problem by considering case specific parameters and restrictions. These are, number of HLA matches between patient and donor, total HLA score of patient and donor pair, PRA existence of patient against a donor, blood group of exchange pairs, age and gender of patient and donor.

In the current problem, HLA parameter is composed of three main groups; A, B and DR. For each HLA type, three cases can happen: case with two matches, case with one match and case with zero matches (which indicate a "mismatch" case). Moreover, while calculating the HLA score of a patient and donor pair; 5 points, 50 points and 150 points are used for each A, B and DR antigen match, respectively.

PRA parameter is another important factor in the problem. A patient having a PRA against a donor's antigen causes incompatibility. Hence, PRA is defined as a binary parameter; if a patient has a PRA against a donor, this parameter takes the value 0 (zero), otherwise, it is 1.

The other parameter, which is blood group compatibility, is incorporated via general blood transfusion rules. In order to perform a kidney exchange, these rules should be satisfied between the patient-donor pairs.

Additionally, some patient-donor matches may not be accepted by the experts of the field or the patients because of gender and age differences. For example; the patient who has a younger donor may not accept an exchange with a pair having an older donor, since a younger donor's kidney is more preferable. Generally, when using the age as a parameter, certain age ranges between the donors of two pairs are taken into consideration. Gender differences also have an important role in this problem. Male donors' kidneys are more preferable than female donors' due to their powerful filtering capability. For this reason, effect of gender differences should also be integrated as a parameter into the model.

As described above, each parameter has to be calculated for each patient-donor pair in the problem, and the most suitable donors for each patient should be determined. However, as the number of pairs in an exchange list increases, an efficient method which automatically evaluates the optimal assignments is required. The lack of such a method in Turkey is the motivation of this study.

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MATERIALS AND METHODS

For the paired kidney exchange problem, an integer linear programming (ILP) based mathematical model which is presented in the following subsections is developed.

Mathematical model for paired kidney exchange

The notation used in the formulation of the mathematical model (PKE_O) is provided below:

Indices

i, j, k	:	patient – donor pair index

Parameters

$page_i$	:	age of patient of pair *i*
$dage_i$	:	age of donor of pair *i*
$pgender_i$	:	gender of patient of pair *i* (0, female; 1, male)
$dgender_i$	:	gender of donor of pair *i* (0, female; 1, male)
pbg_i	:	blood group of patient of pair *i*
dbg_i	:	blood group of donor of pair *i*
nd_i	:	number of donors for patient *i*
HLA_A_{ij}	:	number of HLA "A" match between patient of pair *i* and donor of pair *j*
HLA_B_{ij}	:	number of HLA "B" match between patient of pair *i* and donor of pair *j*
HLA_DR_{ij}	:	number of HLA "DR" match between patient of pair *i* and donor of pair *j*
PRA_{ij}	:	0, if patient of pair *i* has a PRA against donor of pair *j*; 1, otherwise
$bgABOmatch_{ij}$	:	1, if patient of pair *i* and donor of pair *j* have compatible blood groups in terms of transfusion rules; 0, otherwise
$exfeas_{ij}$	:	1, if patient of pair *i* can receive a kidney from donor of pair *j*; 0, otherwise
$HLAscore_{ij}$	:	total HLA score for patient of pair *i* and donor of pair *j*

The total score of paired exchange between pair *i* - pair *j* pair is calculated as follows;

$$HLAscore_{ij} = 5 \cdot HLA\_A_{ij} + 50 \cdot HLA\_B_{ij} + 150 \cdot HLA\_DR_{ij} \qquad \forall i, \forall j \qquad (1)$$

Decision variables

X_{ij}	:	1, if a paired kidney exchange occurs between patient of pair *i* and donor of pair *j*; 0, otherwise

Model PKE_O is given below:

$$\max z = \sum_i \sum_j bgABOmatch_{ij} \cdot bgABOmatch_{ji} \cdot PRA_{ij} \cdot PRA_{ji} \cdot HLAscore_{ij} \cdot exfeas_{ij} \cdot X_{ij} \qquad (2)$$

Subject to:

$$\sum_{\substack{i \\ i \neq j}} bgABOmatch_{ij} \cdot bgABOmatch_{ji} . exfeas_{ij} \cdot X_{ij} \leq 1 \qquad \forall j \qquad (3)$$

$$\sum_{\substack{j \\ j \neq i}} bgABOmatch_{ij} \cdot bgABOmatch_{ji} \cdot exfeas_{ij} \cdot X_{ij} \leq 1 \qquad \forall i \qquad (4)$$

$$X_{ij} = X_{ji} \qquad \forall i,\ \forall j,\ i \neq j \qquad (5)$$

$$\sum_j \sum_{\substack{i \\ i \neq j \\ k \leq i \leq k + nd_k - 1 \\ nd_k > 1}} X_{ij} \leq 1 \qquad \forall k \qquad (6)$$

$$X_{ij} \in \{0,1\} \qquad \forall i, \forall j \qquad (7)$$

The objective function (2) aims to maximize the total score of the paired kidney exchange swaps by considering blood group matches and PRA compatibilities. Constraint sets (3) and (4) ensure that a patient-donor pair can receive and can give at most one kidney from/to another pair in terms of blood group compatibility. Constraint set (5) assures that the exchange occurs between the same patient *i* - donor *j* and patient *j* - donor *i* pairs. Finally, constraint (6) ensures that each patient has to attend the barter with just one donor. For instance, if patient 1 has three donors (nd_1 = 3), pairs 1, 2 and 3 are all pairs of patient 1. Hence, among the first three pairs, only one of them can attend the exchange. The integrality of the decision variables are given in constraint set (7).

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Integration of the age effect

Age parameter is a significant factor on the exchange problem. To incorporate the age effect in the model, certain age ranges between donors of pair *i* and pair *j* are defined. Moreover, Equation (8) which has two new parameters, *at* and *M,* are added to PKE_0. This model is named as PKE_A.

Additional parameters

at : age threshold

M_1 : a very big number

$$\left|dage_i - dage_j\right| \le at + M_1(1 - X_{ij}) \qquad \forall i, \forall j \qquad (8)$$

Integration of the gender effect

Gender differences poses another considerable role in this problem. It is preferable to have an exchange as follows: if a patient's donor is female (male), then the patient can receive a kidney from a pair with a female (male) donor. After adding Equation (9) to PKE_0, gender restriction can be controlled. This model is referred to as PKE_G. M_2 is a very big number.

$$dgender_i - dgender_j \le M_2(1 - X_{ij}) \qquad \forall i, \forall j \qquad (9)$$

RESULTS

In order to test the validity of the proposed models, data representing real life cases are generated. The results obtained are discussed in the subsequent sections.

Data generation

The data generation phase is conducted together with the experts working in the area of kidney transplantation. A sample data of donors and patients are obtained from a hospital which is one of the leading kidney transplantation centers in Istanbul, and the characteristics of the data are analyzed. Based on this analysis, data employed in the models are generated and discussed with the specialists, so as to design realistic situations.

[Table 2] displays the data generated for the parameters of the paired kidney exchange model. As it can be seen from the table, uniform distribution is commonly used in determining the value of the parameters. For example, *HLA* is a discrete uniform random variable that takes values 0, 1, and 2; representing zero matches (mismatch), one match, and two matches, respectively. The age of patient *i*, $page_i$, is also a discrete uniform random variable which has different probabilities for different age intervals. Note that, for each patient *i*, the number of donors generated are denoted by nd_i, and found by using the probabilities given in [Table 2].

Using the data of [Table 2], a list of 40 patient-donor pairs given in [Table 3] is generated. Due to space limitation, only a sample part of [Table 3] is provided here. As it can be seen from this table, P8 and P9 are exactly the same patients having two donors, D8 and D9, whereas P11-P14 denote the same patient with four donors, D11-D14.

Table 2: Data generation for paired kidney exchange

Parameter	Explanation
HLA_A_{ij}, HLA_B_{ij}, HLA_DR_{ij}	U(0,2)
nd_i	"1" with probability 0.85 "2" with probability 0.05 "3" with probability 0.05 "4" with probability 0.05
pbg_i, dbg_j	U(0,3) 0 represents "0" blood group, 1 represents "A" blood group, 2 represents "B" blood group, 3 represents "AB" blood group
PRA	"0" with probability 0.60 "1" with probability 0.40
$page_i$	U(0,19) with probability 0.068,

	U(20,44) with probability 0.609, U(45,64) with probability 0.272, U(65,74) with probability 0.049, U(75,80) with probability 0.002,
$dage_j$	U(20,75)
$pgender_i$, $dgender_j$	"Male(1)" with probability 0.60 "Female(0)" with probability 0.40
$bgmatch_{ij}$	"1", if $pbg_i = dbg_j$ "0", otherwise

Table 3: Patient-donor characteristics of generated data

Patient Data				Donor Data			
Patient ID	Gender	Age	Blood Group	Donor ID	Gender	Age	Blood Group
P1	Female	8	AB	D1	Male	31	AB
P2	Female	3	A	D2	Male	20	B
P3	Female	27	0	D3	Male	34	0
P4	Female	21	AB	D4	Female	47	A
P5	Female	28	B	D5	Female	28	0
P6	Male	24	A	D6	Female	29	B
P7	Male	36	AB	D7	Female	38	0
P8	Female	34	AB	D8	Female	37	0
P9	Female	34	AB	D9	Male	37	AB
P10	Male	27	AB	D10	Female	73	AB
P11	Male	36	B	D11	Female	74	AB
P12	Male	36	B	D12	Male	40	B
P13	Male	36	B	D13	Female	40	0
P14	Male	36	B	D14	Female	62	A
P38	Female	66	B	D38	Female	36	0
P39	Female	72	B	D39	Female	24	AB
P40	Male	75	B	D40	Female	42	0

Results of paired kidney exchange

By using the generated data described above, the proposed mathematical models are solved using GAMS optimization software [18] and CPLEX solver [19]. The characteristics of model PKE_O are listed in [Table 4]. The solution of the proposed model with the default settings of CPLEX version 12.0 indicates that the optimal solution is found at the root node in 0.484 CPU seconds.

Table 4: Characteristics of the constructed model

Item	Value
Number of binary variables	1560
Number of constraints	1681
Number of nodes	0
Number of iterations	39
Solver memory (MB)	4
CPU time (seconds)[a]	0.484

[a]Desktop computer with Intel Core i5 processor and 4 GB of RAM.

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32 transplantation assignments are obtained as the optimal solution of model PKE_0 for 40 patient-donor pairs. Due to space limitation, only three of the paired exchanges are presented in [Table 5]. As an example it is observed that, P11-P14 who is the same patient with four donors has attended the exchange with his donor D12, and has received the kidney from the donor of pair P5-D5.

Table 5: Results of the paired kidney exchange

Patient ID	Gender	Age	Blood Group		Donor ID	Gender	Age	Blood Group
P12	Male	36	B		D5	Female	28	0
P5	Female	28	B		D12	Male	40	B

Patient ID	Gender	Age	Blood Group		Donor ID	Gender	Age	Blood Group
P24	Male	38	B		D2	Male	20	B
P2	Female	3	A		D24	Female	48	0

Patient ID	Gender	Age	Blood Group		Donor ID	Gender	Age	Blood Group
P21	Male	21	0		D8	Female	37	0
P8	Female	34	AB		D21	Female	22	A

Results of Age Effect

As shown in [Table 6], a number of experiments are performed by changing the value of age threshold, *at,* in model PKE_A. The number of *at* is studied for 5, 10, 15, 20 and 25 in a population of 40 patient-donor pairs. For example, when the age difference between donors of pair *i* and *j* pair is less than or equal to 10, the paired kidney exchange model results in 24 transplantations with an objective function value of 5790. However, when the results of models PKE_0 and PKE_A are compared, model PKE_0 has a higher objective function value and total exchange score. As expected, this result points out the fact that, the addition of age constraint will limit both the number of transplants and the total HLA score of assignments.

Table 6: Age effect on paired kidney exchange with different age threshold values for 40 patient and donor pairs

at	Pair Kidney Exchange	
	*z**	*TT*
5	4435	16
10	5790	24
15	6520	26
20	7025	28
25	7070	28
None	8350	32

z: Objective Function Value, *TT*: Total Number of Transplantations, *at*: Age Threshold

Results of gender effect

The comparative results of models PKE_0 and PKE_G for the given 40 patient-donor pairs are displayed in [Table 7]. It is observed that, PKE_0 has better results in terms of objective function value and number of

transplantations. This indicates that adding a gender constraint restricts the number of transplantations, as expected.

Table 7: Gender effect for 40 patient-donor pairs

Gender Restriction	Pair Kidney Exchange	
	z^*	*TT*
None	8350	32
M-M F-F	6360	22

z: Objective Function Value, *TT*: Total Number of Transplantations, M-M: Male to Male, F-F: Female to Female

Implementation at a hospital in Turkey

In order to compare the model's solution with the planned transplantations at one of the leading kidney transplantation centers located in Istanbul, the original patient-donor list provided by the hospital is input to the model. [Table 8] displays the real waiting list of patients and their donors. For example, P9-P12 is a female patient who is 64 years old and has an A blood group type. She has four donors, D9-D12, whose characteristics are shown in [Table 8]. On the other hand, the male patient P13 has a single donor D13 who is a female.

By using the real data given in [Table 8], model PKE_0 is solved using GAMS optimization software [4] and CPLEX solver [18]. For this data set, 4 transplantation assignments are obtained in the optimal solution. As it can be seen from Table 9, pairs P7-D7 and P14-D14 have exchanged their kidneys. The female donor D7 with B blood group type has given her kidney to P14 who is a female patient with the same blood group. In this exchange, the male patient P7 with A blood group has received a kidney from the 0 blood group male donor D14. In the second swap, P9-P12 who is the same patient with four donors has participated the exchange with her donor D11, and has received the kidney from the donor of pair P13-D13.

For this real data set, the hospital could not find any assignments manually. Hence, they shared the data to apply the suggested optimization approach. By the help of the developed model, two swaps are obtained, which is a considerable contribution to both the hospital and the patients. The proposed method automatically evaluates the optimal assignments and eliminates personal mistakes.

Table 8: Real list of patients and donors

Patient Data				Donor Data			
Patient ID	Gender	Age	Blood Group	Donor ID	Gender	Age	Blood Group
P1	Female	62	A	D1	Female	34	A
P2				D2	Female	40	A
P3				D3	Female	56	A
P4				D4	Female	54	A
P5	Female	53	A	D5	Male	52	A
P6	Female	55	A	D6	Female	40	A
P7	Male	42	A	D7	Female	39	B
P8	Male	63	A	D8	Female	55	AB
P9	Female	64	A	D9	Male	41	A
P10				D10	Male	44	B
P11				D11	Male	39	B
P12				D12	Female	42	A
P13	Male	42	B	D13	Female	35	A
P14	Female	60	B	D14	Male	54	0

P15	Female	50	0	D15	Female	40	A
P16	Male	62	0	D16	Male	36	A
P17				D17	Female	33	A
P18	Female	54	0	D18	Male	20	0
P19	Female	50	0	D19	Male	54	0
P20	Female	54	0	D20	Male	69	A
P21	Female	34	0	D21	Male	33	A

Table 9: Assignments of paired kidney exchange model for real data

Patient ID	Gender	Age	Blood Group	Donor ID	Gender	Age	Blood Group
P7	Male	42	A	D14	Male	54	0
P14	Female	60	B	D7	Female	39	B
Patient ID	**Gender**	**Age**	**Blood Group**	**Donor ID**	**Gender**	**Age**	**Blood Group**
P11	Female	64	A	D13	Female	35	A
P13	Male	42	B	D11	Male	39	B

Comparison of decentralized and centralized approaches

In order to compare the results of decentralized and centralized approaches, a random data set for each of the five hospitals in Istanbul that are capable of performing kidney exchanges is generated by considering their location and size. [Table 10] displays the number of patients in the waiting list of each hospital.

Table 10: Number of patients at each hospital

Hospital	Number of Patients
H1	25
H2	20
H3	15
H4	20
H5	13
Total	93

The "decentralized approach" represents the current situation at which the hospitals perform the swaps within their individual waiting lists. On the other hand, in the proposed "centralized approach", hospitals are working in a coordinated manner and sharing their waiting list information with each other. The resultant single common list can lead to the realization of exchanges between two different hospitals. By using the data given in [Table 10], model PKE_0 is run for both approaches. Comparison of the results of two approaches is displayed in [Table 11].

In the decentralized system, while approximately 45% of the patients undergo transplantation, this ratio becomes approximately 60% in a centralized system. Since the exchange and compatibility probability increases with an expansion in the waiting list size, the total HLA score as an indicator of exchange compatibility improves by 53% in the centralized case. Moreover, the number of swaps is increased through coordination. Consequently, it will be possible to minimize both waiting time of emergency patients and post-transplantation complications.

Table 11: Comparison of the decentralized and centralized approaches

Hospital	Decentralized Approach		Centralized Approach	
	Total HLA Score	Number of Transplantations	Total HLA Score	Number of Transplantations
H1	3010	10	4115	13
H2	2045	8	3315	10
H3	1645	8	2180	9
H4	2795	10	4415	14
H5	1830	6	3295	10
Total	11,325	42	17,320	56

[Table 12] gives the distribution of patients and donors matched in the centralized approach. In the centralized approach, appropriate patient-donor pair matching takes place between different hospitals, whereas, in the decentralized approach, transplantations are performed within the pairs belonging to the same hospital. For example, the individual waiting list of H4 results in 10 swaps in the decentralized system. This number increases to 14 in the proposed approach. Among those exchanges, 2 are from its own waiting list, while 3, 1, 3, and 5 exchanges result from the coordination with hospitals H1, H2, H3 and H5, respectively.

Table 12: The distribution of patients and donors matched in centralized approach

Patient's Hospital	Donor's Hospital				
	H1	H2	H3	H4	H5
H1	6	3	1	3	0
H2	3	2	2	1	2
H3	1	2	2	3	1
H4	3	1	3	2	5
H5	0	2	1	5	2

These results are promising and indicate that a centralized approach will be more advantageous in terms of number of swaps, probability of exchange and compatibility.

CONCLUSION

Kidneys are among the vital organs of the human body, and for patients suffering from kidney failure or serious kidney diseases, transplantation is the most desirable treatment alternative. Statistics show that, the number of patients suffering from kidney diseases in Turkey is increasing each year. This study introduces an easy and practical approach to the paired kidney allocation problem. Currently, each hospital in Turkey operates in a decentralized manner. A patient in this list may have more than one incompatible donor, which constitutes the main difference of this work from others in literature.

To solve the paired kidney exchange problem considering all important factors, integer linear programming models are proposed to maximize the total allocation score between compatible patient and donor pairs under some system constraints. GAMS software and CPLEX solver is used to obtain the optimal solutions of the developed models. Different scenarios are generated to measure the impact of "gender differences" and "age" on the solution. Moreover, the real patient-donor list provided by a hospital located in Istanbul is employed in the model for comparison of the model's solution with the planned transplantations. The study also incorporates and evaluates a centralized approach which integrates all the hospitals performing paired kidney exchange in Istanbul. In terms of HLA compatibility and number of transplantations performed, the centralized approach seems to be more favourable in comparison to decentralized approach. During the course of this study, feedbacks have been taken continuously from specialists working in this area.

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As an extension, three-way and multi-way kidney exchange models can also be developed. We hope that this study will be of assistance to the paired kidney allocation problem of the Ministry of Health, and the National Coordination Center in Turkey.

CONFLICT OF INTEREST

Authors declare no conflict of interest.

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FINANCIAL DISCLOSURE

None

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ARTICLE

A SYSTEMATIC APPROACH FOR HEALTH WORKFORCE MANAGEMENT IN TURKEY

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ABSTRACT

Background: *The lack of planning for health workers in the world causes imbalances in health systems. The reason can be seen as the health workforce constitutes the basis for the health system. All the dynamics in the health system are moving with this basic structure. Well managing of human resources in health, requires consideration of population needs and expectations.* ***Methods:*** *Therefore, realistic and feasible planning of the workforce in the health system should be done with a systematic approach. This study focuses on five factors that influence workforce plans in health.* ***Results:*** *Five factors were evaluated at national and international level. In the planning of employees for the health system in Turkey, a framework on how to participate in the evaluation of these factors are presented. Evaluation of sub-headings of each factor on the framework presented some suggestions for planning a sustainable workforce in the health system in Turkey and various deductions are made.* ***Conclusions:*** *It is emphasized that an action plan should be developed for the management of a health workforce, and it is emphasized that the follow-up monitoring processes recommended for this action plan should be done with caution.*

KEY WORDS
Health care management; Health care workforce; Workforce Planning; System Framework

INTRODUCTION

Workforce planning in the health system has become a significant issue due to population growth, the emergence of different diseases, the increase in the number of diseases and migrations. Health personnel have to be properly planned so that patients can access the appropriate treatment in a suitable and timely manner. However, the diversity and number of occupational groups and professions involved in the health care system, the differences in patient needs and patient satisfaction which are dependent on a large scale of factors, are only a couple of the most significant challenges in workforce planning. Besides these difficulties, this status also brings some risks such as human life, increasing illness rates, inadequate health care work, lack of trained personnel for the right place and time, and misleading investments.

The health system possesses a rough structure, owing to its stochastic and dynamic structure, influenced by many external factors. For this reason, scenario analysis have to be implemented in workforce planning. It is necessary to examine at this point which factors influence the demand for labour and supply rather than forecasting the future.

Human resources planning in health is based on the development of strategies that will balance the supply of staff and the demand, besides training of health professionals taken a long time. As a result of unpredictable changes in the financial, political and clinical environment, the determination of what the best evaluation will be, and the best evidence can prevent dramatic errors that may occur in the future [1]. Thus, existing human resources are identified, future human resources needs are designed, and activities are defined to balance supply and demand.

Health manpower planning can be defined as a set of actions aimed at providing health workers with sufficient quality and quantity, uniform distribution, proper timing and correct employment for the health services offered and presented in the future. To be able to give the health services appropriately (everyone and as needed), the training of health human power to carry out these services;

- Equipping with the knowledge, skills and attitudes that can meet the needs of the modern health care,
- Dealing with the problems by cognizance of the team, according to the universal qualities and the facts of the country,
- Planning and employing in a balanced manner across the country.

Human power planning is a necessity to be provided for effective and efficient use of resources, waste prevention of resources and availability of health services. A substantial section of the planning work is taken place in the public sector, resulting from much expenditure was made by community in Turkey. In health manpower planning, it is expected that education and health authorities should make decisions about the distribution and duties of these personnel, as in what qualities and how many number of employees are needed. Unrealistic or inadequate planning reduces the productivity of the system, severely disrupts its operation, increases cost, and causes unbalanced distribution of resources. Therefore, when it is essential to handle with all this stuff, getting health care at the right time and in the right qualities becomes tough.

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Health workforce planning a significant topic for providing the general services of public and private health sector. In the meantime, topics are investigated, it is clearly seen that planning, decision making, scheduling, statistical analysis in various subjects, demand and forecasting studies draw attention. In developing and developed countries, to understand the trend of the general situation of the subjects a lot of case analysis are investigated. For example, Nta et. al. try to find the impact of digital health workforce registry for a Nigerian state, Gray et. al. make a survey study to identify the number and distribution of public health specialists in UK [2-3]. Chang et. al. [4] investigate planning and evaluation in health workforce development in the topic of pharmacy for Taiwan. Johnson et. al. [5] investigate potential attenuation of healthy worker biases in populations in which healthy women of reproductive age opt out the workforce to provide childcare in U.S. Scheffer et. al. [6] study for the state of the surgical workforce in Brazil and deal with the problem put frothing the descriptive statistic of data of Brazilian Federal Medical Board in 2014. AlBaker et. al. because of not having enough study on this topic they described the status of the licensed dentist workforce in their kingdom [7]. Jenner et. al. state that recent UK health policies have consistently stressed that the importance of basing local action on evidence and local intelligence. Therefore, a suitably skilled workforce are needed in the topic. They describe some steps by health observatories and other organizations to grow and train this new workforce [8]. Qi et. al. investigate this topic to explore the current situation and issues related to the development of the public health informatics workforce for different levels of disease control and prevention in China [9]. Similar studies are also done for the country of Romania, Ireland, Indonesia, Germany, Turkey, Italy and Serbia. The studies based above generally head the topic until present.

Due to the methods also, some classifications can be made. Kroezen et. al., Rees et. al., Milicevic et. al., Domagala and Klich, Btenburg, Carey, Humphries et. al. investigate various topics due to the utilizing the planning and estimation methods of different disciplines [10-16]. Vicarelli and Pavolini, Agartan, Barbazza, Boulton et. al., Gallagher and Eaton, Reichert and Tauchmann, Beck et. al., Gabrysch and Jaehn, Leider et. al., Stock et. al., Alyea et. al., Donelan et. al. generally deal within the topic of governance, management and policy of the countries in the topic of workforce health [17-28]. Especially, health reforms which is done in some country or not, generally constitutes the studies. General situation of workforce plan has been recently seen a promising topic due to investigated part. Except of these topics also education and training, creating system structure, performance management, data analysis is the other subjects' studies done in this area.

The area of which workforce kinds are used for the studies can take much attraction. Generally, physicians are used in these studies, but Singhal et. al. dentists, Humphries et. al. nurses, Domagala et. al. physicians are also observed within the studies based in this topic [14, 16, 29].

Also, for understanding the situation of interprofessional health workforce data Spetz et. al. examine progress toward of the main-data related recommendations of Nursing Institution and identify strategies that can achieve further gains in health workforce data collection [30].

When the studies are examined in detail, it is generally observed that the studies about this topic mainly are focused on special aspects of health workforce management. Dubois and Singh [37] describes evidence about the benefits and pitfalls of current approaches to human resources optimization in health care. Fritezen [38] identifies a number of current lines of productive research, focusing on the relationship between health policy reforms and the local institutional environments in which the workforce, both public and private, is deployed.

The structure of the rest of the study are as follows: Examination of criteria for planning of health care workers facing and the current status of Turkey is represented in the first chapter. A framework is presented for the proposed planning stages, based on the criteria set out in Chapter 3. According to the framework presented in the last section there are conclusions and recommendations for the planning of health care workers for Turkey.

MATERIALS AND METHODS

Health labour force planning methods and criteria

Various criteria must be applied in the process of making health-related workforce plans. These criteria provide significant clues as to the development of valuable strategies. Economic, social, demographic and labour measures are guiding the development of strategies in a fundamental sense. [Fig. 1] shows the measures that affect workforce planning in health. When these criteria are examined, it may be seen that the methods used in health workforce planning have to be used collectively rather than alone.

Health care workforce planning possess a significant place in health workforce planning. Data, such as distribution of health workforce by regions and institutions, number of annual graduates and capacities of educational institutions, numbers and capacities of health institutions can be collected under this heading. By analysing these data from the past to present, trends can be followed, and new strategies can be developed by making plans through these data.

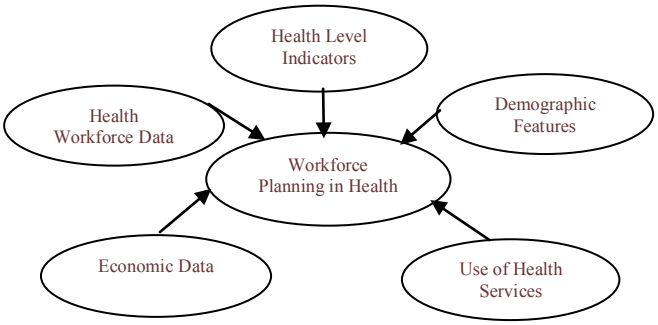

Fig. 1: Criteria affecting workforce planning in health.

Another indicator are demographic characteristics, includes population status by age and sex, geographical distribution of population, population densities and estimation of population changes in terms of birth, death and migration. In this respect, it is necessary to plan the health personnel, according to the population characteristics. It is important that the guidance of health personnel and the capacity constraints are taken into consideration through these data. In addition, the health level indicators belonging to the population possesses a substantial place in this program.

The necessary statistical data related to the health level can be utilized by examining the mortality rates, the rates of illnesses, fertility levels and nutritional characteristics according to regions, age and gender.

This data is used to evaluate the quality and quantity of the workforce in health and at the same time the necessary amount of labour is calculated. Economic data is another planning criterion. Indicators such as national income per capita, per capita health expenditures, unemployment rates, budget for health, social security system are significant for health workforce planning.

There are several reasons why labour planning in the health system may fail. Short and medium-term plans do not overlap with long-term plans. However, the fact that the general health policies are in contradiction with the plans made is one of the most important reasons of failure. The shortcomings of population planning, economic crises, frequent changes in governance, and the lack of information flow between institutions and organizations are affecting the workforce planning made in the worst way. In this respect, healthy planning should be done by considering the necessary factors for effective and realistic workforce planning and by producing permanent solutions instead of temporary solutions. Different approaches and methods can be used to plan health human resources [31].

Health workforce in Turkey

Studies on health workforce planning in Turkey began in the early years of the republic. Especially in the 1960s development plans, the breakthroughs towards the health workforce have gained momentum. In the development plan between 1963 and 1967, a target was set to increase the number of health personnel to 2,5 times of current health personnel. In the second development plan (1968-1972), the establishment of educational institutions aimed at raising the work force in health and the increase of the capacities, determination of staff and wage policies for the balanced distribution of health personnel throughout the country. Similar to the third development plan between 1973 and 1977, there is a balanced distribution of health personnel throughout the country. In this regard, incentives and planning for various incentives are included in the fifth development plan (1985-1989). Throughout the five-year development plans until 2018, there are plans for training of health personnel, balanced distribution within the country and workloads.

Here, also the biggest problems in workforce planning in the health field can be understood in Turkey in general is seen as one dorm balanced dispersal of the workforce. Although, there are various incentives and compulsory regulations in this issue, it cannot be said that the problem has been solved completely. Especially the living standards in the eastern regions are seen as one of the most important obstacles in this issue. Development along the eastern regions of Turkey will bring the solution of these problems.

Health workforce data and demographic characteristics

The number of physicians per 100,000 people belong to the years of 2002-2016 shown in [Fig. 2] for various regions in Turkey and mega-city İstanbul There is an increase in the number of physicians per 100,000 people for all regions. However; Istanbul, Western Anatolia and other regions outside the Aegean remains below the average of Turkey. What is notable in here is that the inadequacy of physicians in the south eastern province is clearly seen. In order to make a more accurate assessment for Turkey it is substantial to evaluate it, in terms of developing and developed countries according to the number of physicians.

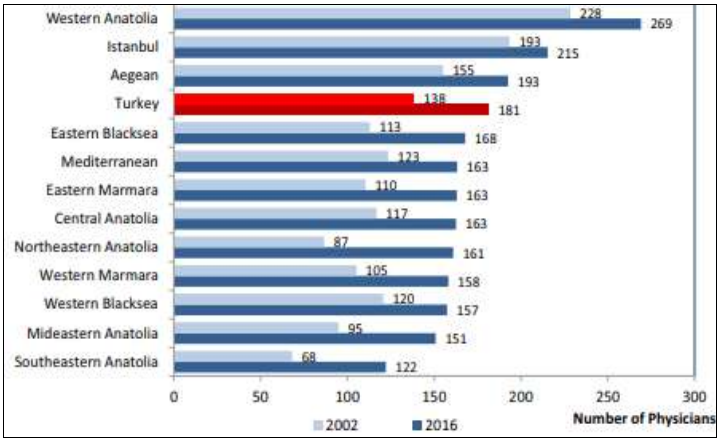

Fig. 2: Number of total physicians. [32]

Turkey is still largely going on with the shortage of physicians. It is necessary to increase the number of physicians in order to get the average of OECD. University hospitals play an important role at this point. The cities which do not have university hospitals will be able to balance regional distribution of physicians as well as increase the number of physicians and the number of patients per physician in developed countries by state support. Establishment of university hospitals is not enough to attract enough physicians. The Ministry of National Education should play a significant role in this planning process, which should be coordinated by all institutions and organizations. Students should be encouraged to become health personnel before university education and the physician should be ingratiated more from primary school.

In recent years, health care organizations with modern standards, begins with being opened city hospitals in Turkey is one of the important developments in improving the working conditions of the patient. However, if the number of physicians is not sufficient, it will not remove the problems in the health system altogether. The length of the patient's waiting period will lead to a decrease in the quality of service in these hospitals. The training of specialist physicians and health personnel in the field is important in terms of drawing these hospitals to a sufficient level in terms of health personnel. Although the number of faculty and medical students in the field of health increased in the last 15 years, the number of academicians and graduate students did not show similar increases. This situation is not sustainable. The key point here is to ensure that the students are directed to the academy to specialize and to provide human resources for the training of new specialists in the field.

Health level indicator

Health level indicators possess a significant place in long-term health workforce planning. Disease incidence rates are indicators that should be considered in order to train specialist physicians in the field of diseases according to their characteristics such as age and sex. This may lead to the development of different strategies among countries. Because diseases, birth and death rates in different regions may vary. For this reason, regional data related to health level should be well analysed and planned in this area. For example, the regions where the Mediterranean Anaemia disease is seen and the frequency of the disease are different in these regions. The training of health personnel related to this disease is essential in areas where the disease is seen intensely.

Compared with developed countries, it is seen that the Turkey does not possess enough physician. It is obvious that the physician's presence is very much in comparison with the population, especially when it is compared with the European countries. For this reason, specialized physicians in the field are needed. Especially, according to needs, specialized physicians in the field should be trained. Especially in paediatric diseases and internal parts, lateral branches are very popular and there is a specialist lack of specialists in the main branches.

Economic data

In the health sector, economic planning is also needed in labour force planning. Because planning is not possible if there is not a system that will feed the health workforce economically. The share allocated to health spending and the amount to human resources in this denominator is one of the factors that affect the labour force planning. Turkey has made significant progress in this regard between the years 1999-2009. However, one of the things that draws attention here is the shortage of current health expenditures in the private sector.

In [Fig. 3], the share in GDP of Turkey's current health expenditures are compared with other countries. Thus, the reason for the low share of health expenditures in Turkey, cannot be reached in less than a

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sufficient number of private health workforce and health undertakings. As in all sectors, private enterprises in certain business areas are more productive than the public sector. Therefore, the provision of stimulating environments for private health enterprises in Turkey, the loosening of restrictions in the health workforce planning will help a serious development in the health field since. It is only possible with private sector initiatives to provide better quality services by alleviating the health burden on the public. The private sector is also in a position to consider its place in the planning of health personnel considering that it provides very serious contributions to the pool of health personnel.

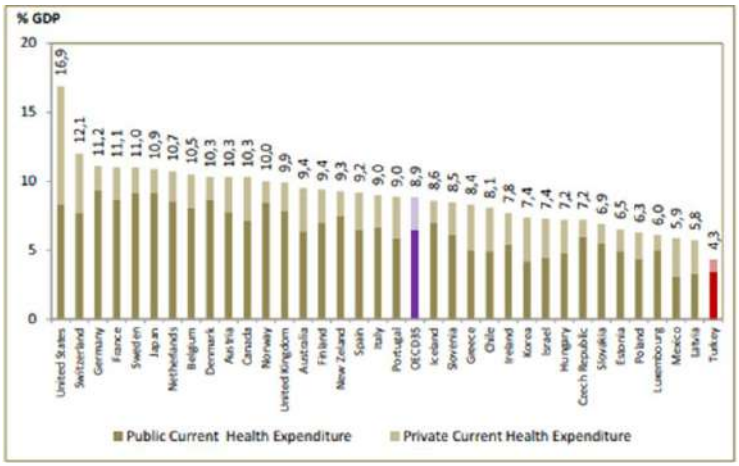

Fig. 3: International comparison of current health expenditure as a share of GDP, (%), 2016 [32].

Another issue that needs to be examined under the heading of economic data is the health insurance status of the people. All citizens of Turkey by the year 2012, has been in the General Health Insurance coverage. If Turkey's population is also taken into consideration from the scope of health insurance, the power held by the Social Security Agency, have reached significant size. The fact that the Social Security Institution also determines the repayment prices of drugs, medical devices and health services has made the institution an important force.

In the US public financing includes elderly and low-income people, the population with private health insurance under 65 is 65% [33]. In France, where the effect of complementary private health insurance is seen, the population with private health insurance is 92%, while in Canada it is 65% [34]. In Germany, where health services are similarly covered by state security, the proportion of private health insurance spending within total health spending is 10%. This rate is 14% for France and Canada [35]. 10.9% of the UK population has private health insurance and the proportion of private health insurance in total health expenditures is 15% [36].

Referring to the examples in the world, the Social Security Institution in Turkey, both in terms of scope as well as the share of total health expenditure is seen to have higher rates. The direct impact of the Social Security Institution on health policies is known, as it is a component of health care in our country. This power, which SGK has, is often discussed at the point of repayment procedures and amounts, especially for health services.

RESULTS

The world population is growing rapidly, not only increasing the expected life expectancy, but also increasing the world's elderly population. Along with these developments, demand for quality health care services is also increasing. The health sector is an existing sector with healthcare professionals. The quality, efficiency and efficiency of health services; is closely related to the quantity and quality of human power in health. It is only through strategic planning and studies that human resources in the health sector can respond quickly and readily to the needs of both demographic change and epidemiological change. In the study, there are five main factors that influence health workforce planning. Short, medium and long-term planning needs to be done considering all of these factors. In [Fig. 4] a general framework is drawn.

The first step is to evaluate health workforce data. The numerical status of the workforce in health, the number of annual graduates from the perspective of health personnel and the regional distribution of health personnel throughout the country, the educational institutions in the field of health and their capacities, the status of health institutions and employment capacities are the indicators that should be evaluated in the first stage. Because, if the current situation is not analysed before planning, it gives wrong results. In the second stage, there are evaluations in terms of demographic characteristics. The evaluation at this stage is based on the quality and quantity of the population of the health care personnel. Forecasts for the future have an important place here. Realistic approaches, especially in long-term planning, depend on the accuracy of the predictions. Health level indicators are in the third stage. This includes assessing the population for health. It is very important that there is information about the level of health of the community so that health personnel planning can be done. The orientation of the healthcare personnel

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from various angles depends on the analysis of the data. In the fourth stage, there is an assessment of the progress of health services in the community. The number and type of applications to health facilities, the status of utilization of health services, the attitudes and behaviours of the community towards health services, and the general complaints and dissatisfaction related to health services are evaluated at this stage. This information is included in the planning process related to the health personnel. At the latest stage, the health system is evaluated economically. Particularly, the share allocated to health in national income is of great importance at this point.

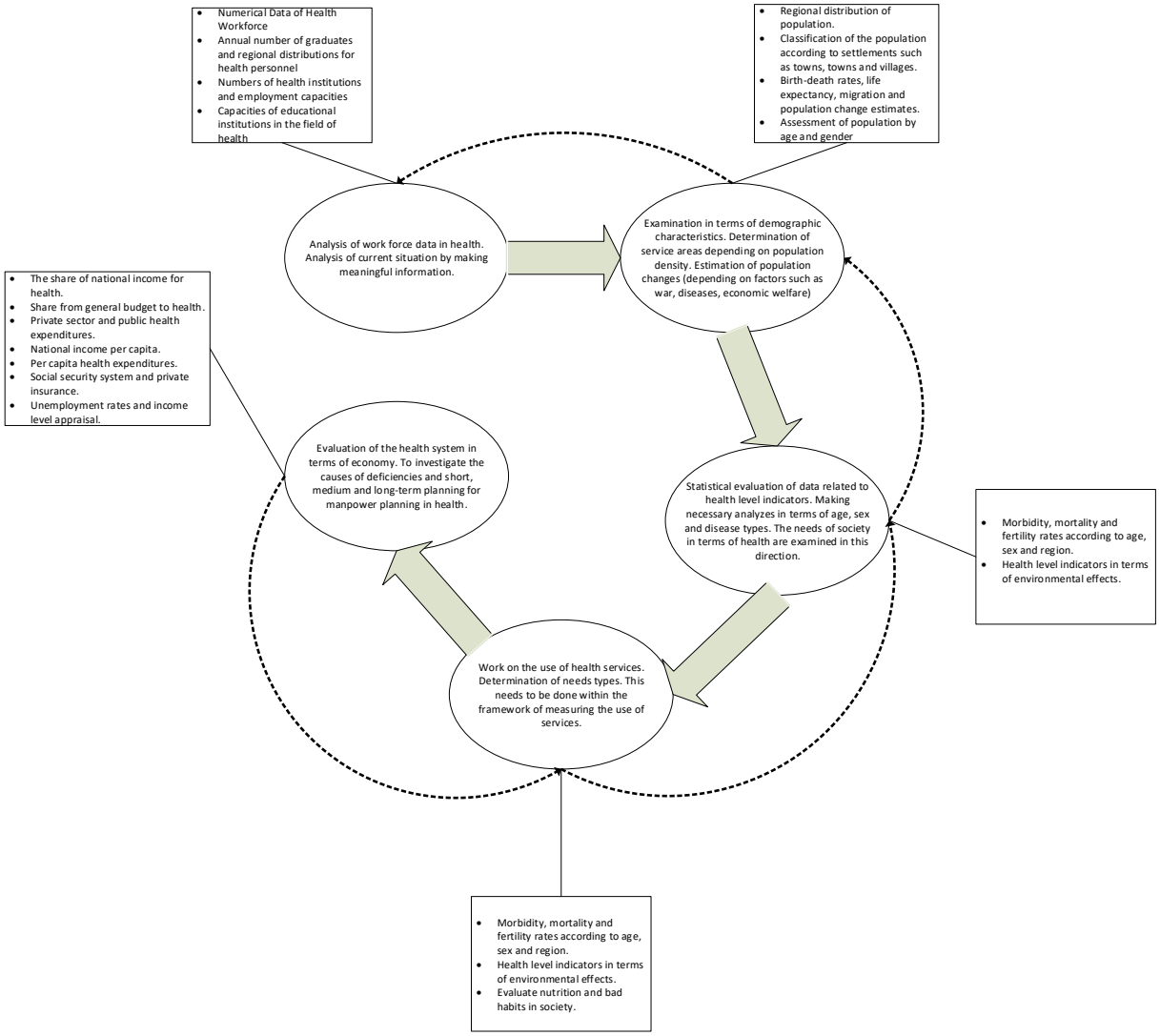

Fig. 4: A framework for health workforce planning.

The general social security system and the functioning of the private health insurance system are another important issue. The economic assessment of the health system has great importance in sustainable health workforce planning. Because the basis of the plans in the health system is the economic infrastructure. Economic infrastructure constitutes state health policies. In this framework, each indicator is evaluated, and the previous indicator is fed back and the health system is considered as a whole. As a result, some output is obtained. Taking these outputs into account, strategic, tactical and operational levels of planning for workforce planning in the health care system are planned.

In determining the general framework of Turkey is made on the basis of examination has been reached the following conclusions:

- Serious lack of work force in Turkey in terms of health are available. In order to overcome these deficiencies, it is necessary to reorganize the quotas of education institutions that provide health work force to provide work force supply and demand balance, and to improve the quality of education and education.
- There are imbalances in terms of regional distribution in terms of health workers. The distribution of sectoral employment among the regions needs to be more balanced.
- It is important to develop the professional qualities of health workers. Some training programs and the spread of well-to-do people across the country will help partially solve this problem. During and

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after the formal training process, the development of language skills and the work in this area should be supported with encouragement.

- Having a very small share of the private health care system in Turkey has captured the public domain. Accordingly, the quality of health services will start to fall after a certain point. The number and quality of health personnel should be developed in the field of private health insurance and economics. Besides, some changes in the social security system can be suggested.
- Turkey, in terms of the diversity of the healthcare profession, stay behind compared to other countries. There are more than 100 professions in different countries that need to be educated about health. It is necessary to diversify the professions in the field of health and to make them available.
- Only increasing employment is not enough for efficiency, and public-sector priorities should be set. The change in health needs to be analysed not only as numbers but also as qualifications.
- The number of patients per healthcare worker should be reduced and adapted to international standards.
- For the incentives that can be applied, first determine what the life threats threatened by age, sex, and region, and determine the disease burden. Incentive areas should be identified in this direction.
- The reputation of health care professionals should be increased. Increased prestige will provide improvements in the promotion of the profession.

CONCLUSION

Human health is the most important asset in the presentation of health services in a community. Health is thought to be the training, employment, planning and prominent topics of health human power to provide effective, efficient and high-quality health services. It is also thought that the distribution of health human power across the country should be considered. Failure to make macro (nationwide) plans for health human resources or inadequate planning and practices may lead to problems in the presentation of health care in the country, incomplete or unnecessary human power and imbalances.

Since 2002, engaged in a very substantial investment in the health sector, Turkey has started to reap the fruit of it in recent years. However, there are still several shortcomings in health care. At the beginning of these, there are problems regarding workforce planning. In this study, a general framework on the health workforce plan was presented. Within this framework, basic steps are taken to plan health personnel. Assessments made through the health care system in Turkey, when it is applied to these steps, a proposal was made for workforce planning under main headings. In general terms, these proposals are concerned with the balanced distribution of health workforce across the country, the development of health workforce in terms of quality and quantity. Here, we have made suggestions about the steps before the planning, the use of the data to be used in the planning, and the criteria on which the planning should be carried out. Labour planning in the health system should be done by taking into consideration the quantitative data and methods along with the suggestions in the framework we specify.

Along with using its capabilities and capacity efficiently, Turkey is capable of having a very strong health care system. Personal planning in the health care system has become an important issue as the building blocks of the health system are people working within this system. According to population and economic terms, Turkey is one of Europe's largest county, demand for healthcare services is greater than the supply amount. This makes labour planning in health a step more important so that the system can be used more efficiently. This study can be ranked according to the importance of the factors that affect the health workforce planning in terms of keeping a light on future studies. Furthermore, depending on different scenarios, short, medium and long-term action plans can be created in the health system and appropriate plans can be set up against different environmental, economic and social situations.

The article which represents a general framework guide future research about the topic of health workforce management. The future research directions are determined in the way of operations research and statistical analysis. For instance, in the presence of the statistics of disease emergence, the physician numbers determined in their branches by OR methods such as modeling, (mixed integer linear programming, assignment etc.) forecasting (arima, decomposition, time series etc.).

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ARTICLE

AN APPLICATION OF LEAN THINKING PRINCIPLES IN A LABORATORY OF A HOSPITAL

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ABSTRACT

The hospitals can gain many benefits by applying lean thinking principles. There are many opportunities for hospitals to decrease the costs and to improve efficiency by improving the processes of hospitals throughout lean thinking. In this paper a university's laboratory has been analyzed by lean thinking principles. Within the context of process improvement studies at the central laboratory of the hospital, the process of lean thinking has been examined. There were 20 units in the laboratory and 16500 test results have been reported, with an average of 900 outpatients and 600 inpatients per day. The wastes in the laboratories have been determined, the causes of these wastes have been analyzed and improvements to eliminate the causes of the wastes have been stated. For certain analyzes in various laboratories, the stages of the processes have been examined with a lean point of view. All stages of the processes have been identified and the activities carried out at these stages have been categorized as activities that add value and do not add value. Suggestions have also been made for the removal of activities that do not add value.

KEY WORDS
Lean thinking,
Lean hospital,
Lean Laboratory

INTRODUCTION

In many hospitals, lean thinking principles and tools have been utilized in various parts of the laboratory, including clinical laboratories, blood banks, microbiology and anatomic pathology. Many lean journeys start in clinical laboratories because the test volumes are very high and cycle times are the fastest and they are the most critical areas. Clinical laboratory samples may be delayed in many stages in value streams, such as collection of samples, receipt of samples, or testing sites [1]. The similarities of the laboratories with the production lines are considerable. For this reason, the application of lean manufacturing techniques in laboratories will provide significant benefits [2,3].

There are many studies done in the hospitals to evaluate the applications of lean techniques in healthcare. A study applied in an emergency department of an university hospital showed how lean techniques can be adopted in order to reduce wastes in hospitals [4]. A case study in a clinical laboratory has been done to demonstrate how the concepts of value stream mapping and process optimization can be applied in healthcare[5]. In a clinical laboratory of a super specialty hospital, the lean methodology has been applied to reduce the turnaround time of the clinical laboratory[6]. To examine the application and outcomes of applying all of the seven lean flows to pathology laboratory remodeling as part of a lean rapid improvement, a research has been done [7]. A descriptive cross-sectional study was carried out to examine the level of usage, barriers and enablers, impact of lean tools in the Namibian medical laboratory services. Findings from the survey showed that the perceived impact of lean tools on the medical laboratory industry was positive. Lean tools were perceived as instrumental for the observed improved operational performance, shortened TAT, improved employee motivation and reduced cost [8].

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It is important to understand the objectives and the criteria before starting a lean journey. As the criteria; number of complaints, cost and quality, number of patients on the waiting lists, number of employees, hours worked, patient experience, waiting days, employee morale, turnover times, number of accidents and defects can be defined. Data on the current situation should be collected when the objectives and criteria are decided. In the basic case, collecting data is not always easy. When information can not be obtained from digital platforms, information must be collected manually [9].

After understanding what the value is according to customers, it is necessary to define and analyze the flow of activities in creating the value for customers. In this analysis, all activities and events in delivering the product or service to the customer and the flow of information supporting the activities of value stream are defined.

The main point in lean thinking is to provide flow. All activities are carried out to ensure flow. When examining laboratories with a lean thought point of view, it should be assessed what prevents the flow in the laboratories. From this point of view, when the processes are evaluated, it can be seen that all the waiting times interrupt the value streams. In lean laboratories, it is aimed to deliver the results of the analysis of blood samples to the patients and doctors as soon as possible with minimum resources.

LABORATORY WASTES WITH LEAN THINKING PERSPECTIVE

When the processes in the laboratories are examined according to the lean thinking principles, the wastes seen in the laboratories can be stated as follows;

- Blood samples rejected due to reasons such as the absence of a bar code, the lack of adequate blood samples etc.,

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- Blood samples waiting for the next procedure,
- Blood specimens are transported between sections or equipment,
- Movements, depending on the staff, equipment and walkways between departments,
- Equipment breakdowns,
- Wait for confirmation after blood samples have been analyzed,
- Blood samples waiting in parties,
- Unbalanced workload related to the volatility of demand, which is the characteristic of the process; because of this it is very busy at some hours and the waiting time is high and if the demand is low, the idle capacity is high.

The most important reasons of waste in laboratories are the characteristics of the demand variability, the poor layout, the processing of blood samples as batches, the differences in the cycle times in the process stages, and the difference in cycle time and takt time. In laboratories, waste can occur in processes, depending on the cycle time and the takt time. At any stage in the value stream, the cycle time is greater than the takt time, indicating that the patient requests cannot be met and the waiting times for the patients are unacceptable. For this reason, it is necessary to balance the cycle times in the value stream and not to have a longer cycle time than the takt time.

One of the most important causes of waste arises from workplace arrangements. In laboratories, workplace is usually determined on a departmental basis rather than on employee movements or flow of blood samples. In particular, staff working at night shifts or on weekends can walk between equipment that are very far from each other. As a result, waiting times for blood samples and flow times may increase.

Transferring blood samples as a batch between the centrifuge device or the blood separating device and the section where analysis is performed reduces movement expenditure. However, flow times are increasing due to the increase in waiting times of blood samples between devices.

Workplace layout is crucial in reducing employee's walking needs and distances. A good layout that considers the flow of blood samples has very important implications for eliminating wastes due to staff walkthroughs and reducing the need to move as parties. At the basis of lean thinking, there is a single piece of flow rather than being processed as parties. In the case of processing in batches, the first processed part must wait for the last processed part. This also means that the flow time increases.

AN OVERVIEW OF THE PROCESSES IN LABORATORIES

Polyclinic patients register at the registration desk when they come to the laboratory, than they take barcodes, tubes and their sequence numbers for bloodletting. Blood is taken from the patient in the blood-taking department. Blood samples are collected by pre-laboratory periodically and then they are being recorded, centrifuged and separated by the blood separation device. Relevant laboratories take blood samples separated from the preliminary laboratory at regular intervals and analyze these blood samples. With the approval of the results obtained from the analyses, the process is completed. Barcodes for inpatients are taken at the relevant service center. The personnel collects blood samples from the relevant departments at specific time intervals. They follow the same process as policlinic patients after being recorded in the pre-laboratory phase. Blood samples of emergency patients come from the central laboratory with the elevator and are recorded here. They are then transferred directly to the laboratory and the centrifugation of the blood samples is carried out in the relevant laboratories. Some emergency blood samples can be centrifuged at the pre-laboratory stage after registration. In order to distinguish emergency blood samples from other blood samples, the tubes of these blood samples are in blue color. Thus, the relevant laboratory can quickly identify and prioritize the urgent ones.

LEAN APPLICATIONS IN LABAROTORIES

There are very important opportunities for blood samples to reduce waste and reduce flow times during the collection and separation phase. Significant gains in flow times can be achieved with the reduction of wastes in the process and the improvement of the flow of blood samples.

Evaluation of causes of rejection of blood samples

Rejection of the blood samples can cause important wastes such as to rework, movement, transporting, waiting time. The reasons of the rejection of blood samples have been analyzed to eliminate the wastes. A pareto diagram based on the rejection values of the blood samples from the inpatients is shown in figure 1. As seen in [Fig. 1], the most important reasons for the rejection of blood samples from inpatients are the samples without barcodes. When the samples without barcodes are prevented, the rejection rate of the blood samples coming from inpatients will be reduced significantly.

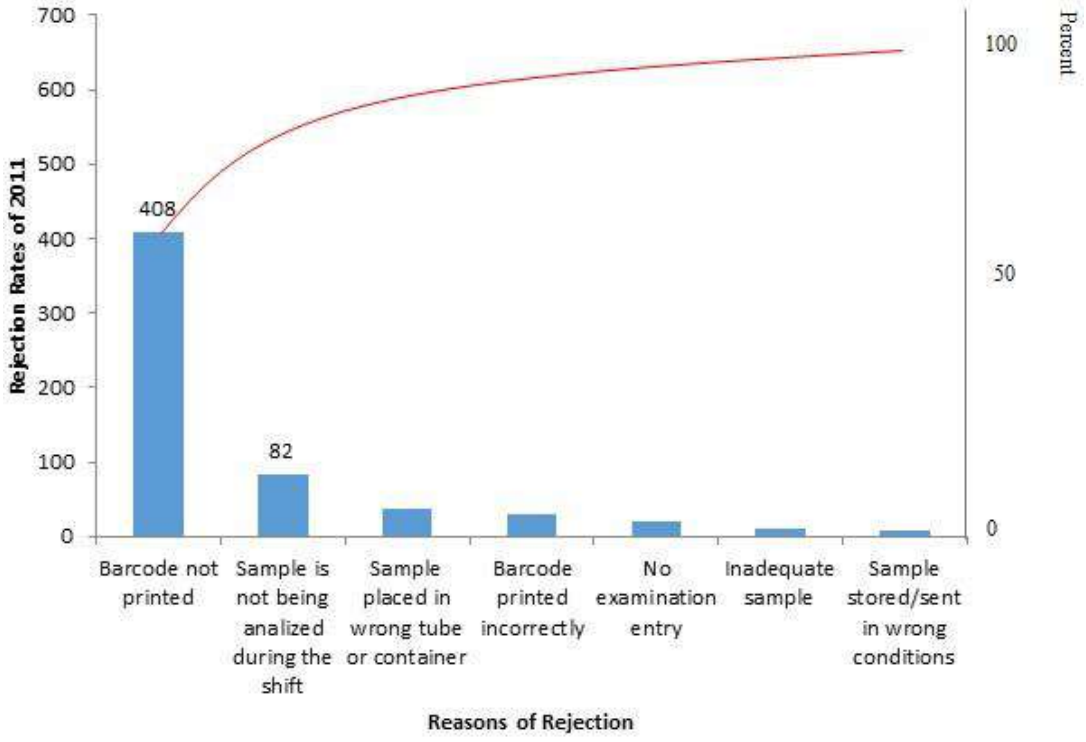

Fig.1: Pareto analysis for the rejected values of blood samples from inpatients.

Reasons of rejection of blood samples from laboratories also examined. The reasons of rejection of blood samples form laboratories can be summarized as;

- Samples with clot,
- Inadequate sample (Hematology laboratory evaluates inadequate samples as inappropriate sample),
- Inappropriate sample,
- Hemolyzed sample,
- Other (sample on the way, not working in that shift, acceptance is not working, false request, technical fault, missing parameter, repetition needed.

By determining the reasons of the rejection of blood samples and finding the ways that cause the rejections of the blood samples in laboratories can provide many benefits on the way of lean journey.

Calculation of mean of number of steps per sample and mean of distance per sample in laboratories

With a lean point of view, walking of laboratory personnel and transportation of blood samples between laboratories and equipment are wastes. In this context, the number of steps per sample and the distance per sample were calculated for the staff under the assumption that there is no difference in walking distances between the blood sample numbers analyzed and between the days of the week and the staff in the laboratory. The number of steps and walking distance of the personnel are calculated; the blood samples are taken from the preliminary laboratory step and carried to the relevant laboratory and the blood samples are loaded on the related equipment. Here, only the average number of steps per sample and the average distance per sample were calculated based on the personnel thought to perform the most walking activity in the laboratory. However, since there is more than one staff member in a laboratory, the average number of steps per sample and the average distance per sample should be calculated by calculating the average number of steps and average walking distance for all staff. The average number of steps per sample and average distance per sample for a staff member in laboratories are shown in [Table 1].

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Table 1: Number of steps per sample and distance per sample in a laboratory

Laboratory	Number of Daily Analysis	Number of daily steps for a staff member	Number of Steps per Sample	Daily Distance for a Staff Member (Meter)	Distance per Sample
Preliminary laboratory	3500	4200	1,2	2980	0,85
Endocrine	450	3243	7,2	2306	5,12
Biochemistry	1200	2587	2,15	1840	1,53
Serology	150	1989	13,26	1414	9,42

Evaluation Of activities that add value to the laboratory or not

For certain analyzes in various laboratories, the stages of the processes have been examined with a lean point of view. In this context, average times (8.00 am - 17.00 pm) were determined for the polyclinic patients and the inpatients from the printing of the barcode to the approval of the results. At each stage, value-added activities and their duration were determined and the percentages of activities that add value and do not add value at were determined.

The stages have been determined as follows;

Sample acceptance period: The time between the printing of the barcode and the acceptance of the blood sample by the preliminary laboratory.
Laboratory acceptance period: The time elapsed between the acceptance of the blood sample by the preliminary laboratory and the acceptance by the laboratory concerned.
Result entry time: The time between the acceptance of the blood sample by the relevant laboratory and the receipt of the analysis result.

Result confirmation time: The time elapsed between the time of the last analysis of the blood sample and the confirmation of the blood sample analysis result.

In [Table 2], the percentage of value added activities for the stages of TSH analysis for policlinic patients in endocrine laboratory and in [Table 3], the percentage of value added activities for the stages of TSH analysis for inpatients in endocrine laboratory have been shown as examples of studies made in the laboratories.

Table 2: Analysis of TSH samples for policlinic patients

TSH Samples	Sample acceptance	Laboratory acceptance	Result entry	Result acceptance	Total
Duration(Policlinic patients	42	100,82	126,04	63,69	332,55
Total duration(%)	12,6	30,31	37,9	19,15	
Duration of the value added activities	5	41	30	1	77
Value added activities(%)	11,90	40,66	23,80	1,57	23,15

Table 3: Analysis of TSH samples for inpatients

TSH Samples	Sample acceptance	Laboratory acceptance	Result entry	Result acceptance	Total
Duration(Inpatients)	95	100,82	126,04	63,69	385,55
Total duration(%)	26,64	26,14	32,69	16,51	
Duration of the value added activities	5	41	30	1	77
Value added activities(%)	5,2	40,66	23,80	1,57	19,97

As shown in tables, 23,15% of activities performed for TSH analysis of polyclinic patients in the endocrine laboratory and 19,7% of activities performed for TSH analysis of inpatients are value added activities.

Reducing waiting times between processes of blood samples

In order to analyze the blood samples separated and centrifuged in the blood sorting equipment, the relevant laboratories go to the preliminary laboratory at certain intervals and blood samples are brought to the relevant laboratory. As seen in the review of the value stream, blood samples from the blood separation device and centrifuged can be waited to be taken from the relevant laboratory. In some cases, the incoming personnel are not able to return blood because they do not have blood samples to be analyzed from the laboratories, and an unnecessary activity has been carried out in the laboratory and preliminary laboratory stage. Waiting is not a value added activity for taking blood samples from preliminary laboratory to the relevant laboratories. It is necessary to reduce unnecessary movements of staff between the laboratory and the preliminary laboratory and the waiting. For this purpose, the pitch

values between the laboratories and the preliminary laboratory were calculated and shown in [Table 4]. According to these values, it was determined how long the blood samples should be taken between the laboratories and the preliminary laboratory and transferred to the related laboratories. It was accepted that it would be appropriate to carry blood samples in 10 units while the pitch values were calculated.

Table 4: Pitch values for laboratories

Laboratory	The average number of patients between 8.00-12.00	Takt time	Pitch	The average number of patients between 13.00 -16.00	Takt time	Pitch
Endocrine(TSH)	193	1,24	12,4	23	7,82	78,2
Biochemistry(Glukoz)	403	0,59	5,9	49	3,67	36,7
Serology(HBsAg)	39	6,15	61,5	10	18	180
Immunology	13	18,46	184,6	6	30	300
Hematology(HgB)	530	0,45	4,5	92	2,6	26
Coagulation(INR)	125	1,92	19,2	30	6	60

Blood samples are kept in a specific area for retrieval by the relevant laboratory after exiting the blood separation device in the preliminary laboratory stage. In order to minimize the waiting of removal of the blood tubes from the blood collection device, a system (voice warning or a lamp warning) can be established on the blood collection device to inform the laboratory that the blood samples are ready for analysis. Thus, the waiting time can be minimized for blood samples from the blood separation device to be taken from the relevant laboratory.

Patients after registering at the front desk sometimes go to other sections in hospitals, and can come back to give blood 3- 4 hours later. In this case, the time between enrollment of the patient and enrollment of the patient's blood sample in the laboratory can be quite high. If the nurses who receive the blood of the patient have hand terminals, recording the blood sampling time and logging in from this point on the system will make the flow times for the blood samples more realistic. At the same time the staff of the preliminary laboratory stage will not need to register because the registration of the hand terminals and the laboratory entry of the blood sample will be made directly. If the blood sorting device can also make the laboratory record, there will be no need to perform manual recording. Thereby, there will be no need for waiting for the blood to be taken, for waiting to be loaded on the respective centrifuge and blood separating devices after taking the record.

In the laboratories, the workplace is usually organized according to departments and is not performed according to the progress of the blood samples in the process or the movement of the personnel. The distance between the centrifuge and the analysis areas causes the blood samples to be transported in batches. These parts cause delays and prolongation of flow times by reducing movement waste. In laboratories, a rail system can be installed to provide continuous flow to reduce downtime. If all devices are connected to each other with the rail system, the waiting time which is wasted according to the lean thinking can be reduced and the activities in the preliminary laboratory stage can be minimized. Continuous flow of blood samples can be achieved with the devices connected by automation.

The blood samples for analysis show significant differences from the days of the week and the hours of the day. With the cross-work system, division and staff can be supported from other departments during peak hours. When a certain number of patients are waiting for their blood to be taken, support can be provided with additional staff to assist the blood-taking staff.

Measuring flow times

Flow time is a very important indicator in measuring the performance of laboratories. Flow times in laboratories are usually measured by analytical method. It should be assessed from the viewpoint of the customer that the activities add value to the concept of lean thinking. The important point is the time between the patient's applications for blood analysis until the approval of the results. In some cases, although the time for an analysis is low, the duration of another analysis carried out with this analysis can be long. In this case, the length of time that the results reach the doctor depends on the long analysis.

The time elapsed between the receipt of a barcode by a patient and the approval of the test result shown in [Table 5] as an example. As shown in [Table 5], If fT3, fT4 or TSH are present, the analyses prepared in the biochemistry laboratory are waiting for a period of 70% of the completion time of the analysis.

For this reason, it is considered to be more appropriate to evaluate patient-based rather than analysis-based evaluation of flow times with a lean point of view.

Table 5: Flow times according to TSH analysis

	Without TSH	fT3, fT4 or TSH present
Time between barcode date and date of blood collection	8	8
Time between blood collection and blood separation date	23	23
Time between blood separation date and laboratory acceptance date	66	87
Time between the laboratory acceptance date and the device dispatch date	9	49
Time between sending to device and working date	44	30
Time between work date and approval	21	95
Total time	**171**	**292**

Measuring the leanness of laboratories

There is continuous flow at the base of lean thinking. In order for continuous flow to be achieved, activities that do not add value to the process should be abolished and the wait between the stages in the process should be minimized. The leanness of laboratories can be evaluated according to the proportion of activities that do not add value in the processes. Laboratories will be able to increase the level of leanness to which they can remove unnecessary activities from the process.

In laboratories, the main causes of waste can depend on variability in demand, workplace arrangements, batching and non-transaction of blood samples, cycle time differences in processes, and the difference between cycle time and takt time. An important indicator when measuring leanness is the difference between the cycle times in the value flow and the takt time. Balancing the cycle times of the steps in the value flow and not having the cycle time greater than the takt time is very important in reducing the waiting times of the patients.

The leanness of laboratories can be assessed according to the level of these wastes. Laboratories with low levels of waste will also have a higher level of leanness at that level. In this context, the following indicators can be used when measuring leanness in laboratories;

- Rejected blood samples (the ratio of rejected blood samples during a period to the total blood samples during a period)
- Moving distances of blood samples (the walking distance between the point a blood sample is taken and the equipment blood sample is analyzed)
- Flow times assessed on patient basis (the time between the patient's applications for blood analysis and the approval of the results)
- Value adding activities / Total time
- Centrifugal efficiency
- Batch size for centrifuges, lot sizes for carriage between laboratories, batch sizes for processing in equipment, batch sizes for approval
- Variation level (for lean purposes, one of the aim is to reduce variation, balance the workload and balance the run time and cycle times which is crucial to reduce the variation over time).

CONCLUSION

The main point of lean thinking is to analyze all the activities as value added activities or non value added activities according to the customers' viewpoint. By eliminating the non value added activities, it can be possible to increase the efficiencies of the processes of manufacturing firms and service firms. In this paper, a laboratory of a university hospital has been analyzed according to the lean thinking principles. The wastes of the laboratories have been evaluated and some improvements have been suggested to eliminate the wastes. The waiting of the blood samples between the stages prevents the flow. So it is possible to decrease the flow times by determining the reasons of waiting of blood samples between the stages and to eliminate the reasons of waiting of the blood samples. By analyzing the processes of the laboratories it can be possible to reduce the Waiting times of the patients, to increase the efficiency of the processes, to increase the service quality. There are many possibilities to decrease the waiting of blood samples between the stages with lean thinking principles.

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ARTICLE

DIGITAL MARKETING SYSTEM MANAGEMENT FORMEDICAL TRAVEL COMPANIES

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ABSTRACT

Purpose: *There appears to be a need in the industry for a guide explaining how to build and benefit such a professional looking online identification as a medical travel agency. The main purpose of this article is to guide the companies on building a successfully working online reputation.* ***Method:*** *The recommendations are made regarding to the experiences of applications made in the author's own medical travel agency as well as the consultancy services given by, and their findings.* ***Findings:*** *Findings of the article suggest systematical management improvements aiming increasing profitability of the investments made online. In addition, improvements in technical requirements and process communication have a high impact on customer attraction criteria.* ***Practical implications:*** *The results of this study can be used by the medical travel agencies either with or without professionally working marketing departments aiming to improve their online reputation. Also, as a report for those willing to follow the continuously changing trends of e-marketing in the sector of medical travel.*

KEY WORDS
Health management, medical travel, digital marketing, systems management

INTRODUCTION

Having a successfully built online reputation provides medical travel agencies new channels to reach the customers with very high levels of return-on-investment rates. The way to perform successfully over all the e-marketing channels depends highly on understanding the system and constantly changing trends of digital world and reacting accordingly. In addition to all these, customers must be very well segmented by a professional approach so that the correct channels can be developed to reach them. Unless managed systematically, having very well looking online profiles won't allow the company to benefit digital tools efficiently and cause the company to lose competitive advantage.

According to researches and experiences, on both medical tourism market and on any other markets, it is proved that the key success of the social media management is posting relevantly and systematically, also; the content is significant, similarly to the website. Because the most likely ways that a potential customer can reach the company are over Google or social media.

This paper seeks to provide a guide for medical travel companies aiming to implement a system for increasing their online reputation. Because maintaining in a professional way increases the company's online reputation efficiently, it must be highly prioritized.

In this study it's claimed that mainly, there are 2 ways to achieve success; either by outsourcing or building an online marketing team inside the company. Both ways have pros and cons. Building a team provides the company to have a continuous development chance and to keep the continuously gained e-marketing know-how inner the company and helps to manage their gate to online world in a better and agile way. Whiles outsourcing makes it faster to get into the action directly and also easier to manage; by increasing the maintaining expenses with a rational reason.

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LITERATURE REVIEW

In recent years, many improvements are going in the field of digital marketing for tourism companies, especially for the ones working in the medical field. Therefore, searches have been made with the keywords can be related with the title, and as the lack of a descriptive guide to build a system was discovered, the decision to write this paper was taken. According to the survey, the authors in [1-4] presented information about the technical side. Each page has to be adequate level of readability score and this can be measured with The Flesch readability index [FI]. Trendy methods should be applied to make necessary improvements for Search Engine Optimization [SEO], Analytics server choosing to catch up with the market requirements. In addition, server choosing should be made by taking into consideration the focal segmentation. Throughout the guide online marketing was considered as one of the most important marketing activities; therefore, most of the literature review was conducted in this field with two distinctive ways of ads and segmentation. Differences between push and pull marketing approaches are given and clarified. Data collection can be collected through a Customer Relationship Management [CRM] software, so that the segmentation can be made accordingly [5,6]. While designing the conversation processes for the online ads, the data coming from previous activities can be used [7,8]. As for all the processes in any company, if available, data should be used for decision-making processes and in digital marketing, this is mostly about building/using models leading to calculate Return on Investment [ROI] to compare the existing options [9-11]. By looking at ROI rates, inner solutions or outsourcing options should be compared, in some cases either one can be more profitable, especially in the beginning phases [12].

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ONLINE EXISTENCE

Because medical travel business focuses on reaching customers from foreign countries, traditional marketing channels are impossible to conduct with reasonable prices and in this situation, it is the best option to navigate modern marketing channels.Website optimization, User Experience Design [UX], and social media management are 3 aspects should be dealt to have a successful online existence.

Website optimization

As online existence for any kind of business starts with owning a website, designing a customer-friendly looking and functional website should be the first step for medical travel agencies and companies. Front-end design, also called as User Interface Design [UI], and the technical background are two fundamental parts of a website.

UI (User Interface Design)

User Interface Design [UI] is a widely used term which means the design of a website that can be seen by the visitors. There are 3 crucial factors of having a successful UI in general; following up-to-date trends, filling the website with relevant contents according to website's purpose, and increasing the readability of the pages. As the customer behaviors are changing very frequently in today's world, following the changing strategies of keeping the attention on a website continuously is also a difficult task for website owners. By hiring an experienced staff for UI or outsourcing this service for the first step, the companies can hold the visitors longer on the website and introduce themselves better. After the attention is kept on the website, relevant content should be filled and separated to the pages appropriately to give the visitor a smooth experience. While filling the content, there are general rules should be obeyed for increasing the readability. As Llinás (et. al.) mentioned, there is a highly used index named The Flesch readability index [FI] which relates text difficulty to word and phrase length and which has its own score range from 0 to 100. It is considered that the page has adequate readability as soon as the score is higher than 60 [1]. By following the trends, filling the content in an appropriate way, and keeping an eye on the scores of readability; a successful UI can be had and the conversion rates from the website can be increased.

Technical background

For technical background, in addition to UI, there is also a part of a website which should be managed by the experts and cannot be reached by the customers. As the UI is a significant part for the customer experience, the technical background is also a more crucial element for a website as it keeps the website online, collects the visitor data which can be defined as potential customers, and affects the UI directly by increasing/decreasing loading time of pages. In order to track, manage, and plan the customer interactions, a Customer Relationship Management [CRM] application may be installed; by maintaining a CRM, the communication process with the customers can be improved, well-managed and in returns, the conversion rates over the interactions can be increased. To create leads to the CRM autonomously, there are 2 main ways of customer data collection: Over the website visits (organic) and over the ads given on various platforms. Google Analytics [GA] is the most famous and accurate tool for collecting data over website visits. As Podpleska (et. al.) stated, GA offers nearly every metric a website manager can need like bounce rates, average time spends on every page, and specific performances of pages [2]. The other way to collect customer data is through Facebook's official toolkit: Pixel. When it comes to the concordance of UI and technical background, it is highly recommended to conduct the server selection process with experts as the server has a huge impact on the website loading time. The importance of the server location selection can be seen on the following experiment: "We examined the differences in user browsing habits due to location and time of access using an actual proxy trace data. Our tests confirm our hypotheses that server location and time of access indeed have an effect on the heterogeneity of website requests [3]".

UX (User Experience Design)

User experience, one of the most trend terms in marketing these years, is how the information flow/action plan/cognitive process [Fig.1] is conducted. Therefore, this flow must be designed by well-experienced information architects in order to reach to a high level of find-ability as that is one of the most critical success factors. The amount of the information, and the way it is structured, which means how it is built with what type of connections, play the most significant roles. When visual design (aesthetics), UI design and communication process [Fig.1] architecture brought together by correct interaction plans, the system is abler to drive the customer to the point wanted by the company, therefore the whole organization plays a role to bring up the distinctive UX which could bring the success to a company.

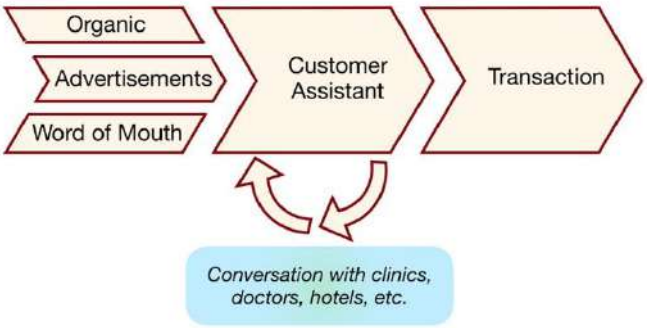

Fig. 1: Chart showing the UX process.

Customer assistant

Customer assistant is located on the point of the value chain where social attributes play the highest important role. Therefore, high level communication skills are required in order to conduct the conversation with a wide variety of people whilst demonstrating a well-prepared vocabulary with an audience-tailored language, listen effectively, offer your ideas appropriately and actively, write clearly and convincingly in order to convince the potential customers reached either organically or by ads. So that the customers can be persuaded. An ideal customer assistant should be able to perform well in any platforms of communication, messages, e-mails, phone calls or even F2F appropriately to ensure the corporate image consistency. In this point, lingual differences may cause significant problems so the company's staff should be prepared/educated in terms of these. In 2004, it was stated that to develop the profile which would provide a competitive advantage, HR is highly responsible for finding the customer support who fulfills the criteria depending on the customer profiles [13]. Hence, a customer assistant should be picked carefully enough, as the bridge between the first touch and sales moment would be under her/his responsibility. And the actions should be optimized periodically to plan improvisations.

Customer regaining strategies

Customer regaining strategies of medical travel agencies should be supported by CRM software in order to keep the track of communication with customers and apply optimization strategies to the UX where necessary. Highest benefit of keeping such track is indeed owning valuable customer data to carry out conversion optimizations. For better conversion optimizations, indeed trendy digital solutions can be used, especially for digital marketing staff who are not highly experienced. In addition, timing strategy is one of the main components of what affects the success of regaining customers. As Thomas, Blattberg, and Fox found, the amount of time spent between first touch and conversion activity is reversed U-shaped; which means that in short and long terms the likelihood of success at reacquisition is lower whiles acting in mid-term (correct timing) means more chance of success [7]. Secondly, it is made easier by design tools specifically for optimization, which allows to configure the designs purposefully, assign them among the users and measure the results by keeping records afterwards [8]. In a nutshell, benefitting such kind of software solutions by the help of an experienced team would affect the company's speed of growth significantly.

Social media management

In today's world of marketing, social media is a must for any business willing exist online; not only to stand out in its field, but also not to have a bad image in the customers' mind. Also, through its usage, a wider audience can be reached either by ads or non-promoted content which is designed accordingly to the relevant customers' segments. Having a vigorous existence on all the major platforms, from LinkedIn to Facebook and more, is almost an obligation for any company willing to increase online reputation to reach the marketing goals by creating a way to engage with the customer more interactive than ever. For so, after planning the customer segmentation, which channels to use should be planned and frequency, content, design, etc. must be planned according to the targets and the corporate language aimed to achieved.

Content planning

In social media management, content planning is what comes right after segmentation, as it is what is seen on the customer's side. From the frequency to the fonts used, any detail of content management is important in terms of matching the customer's demand. However, it should be kept in mind that to me up with a game-breaker-level campaign with astronomic ROI rates, is mostly an eccentric/unexpected campaign which becomes viral by attracting attention of the audience. It is stated by Rababah that most of the SEO models nowadays, neglect the local and cultural characteristics of the audiences [4]. Therefore,

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these mistakes should not be made and all the attributes of the content should be in harmony with the audience's demand.

Brand image

Brand image for companies existing solely online is how the company's appearance remains in the customer's mind, therefore consumer behavior/expectation must be taken into consideration well so that the action plan for the brand image can be created accordingly. Besides the content production/design, posting frequency also matters while developing the brand image. As stated by Frick, an experienced team of people who has enough information about who the target audience is and what they need, can develop a strategically designed website by the help of design experts to meet the needs of business and digital marketing [5]. Besides those, the language used within the communication channels of the company should be structured as consumers tend to valuate corporate language more and more nowadays.

REACHING TO CUSTOMERS

Reaching to customers is a long process starting from a lead and ending up with a conversion; which means achieving the goal [Fig. 2]. The main purpose of existing online is firstly to receive leads, and then to convert the leads into sales. While reaching to customers, online ads and getting organic leads are 2 main topics to focus on.

Fig. 2: Lead flow of the customers. (Source: https://fitsmallbusiness.com/lead-generation-ideas/)

Ads

Online Ads, online marketing or internet-based advertising, web advertising or digital advertising; all of are standing for the ads which would drive leads through various channels online by conveying the marketing subject to the potential customers. For medical travel agencies willing to have a good reputation online, SEO and social media features work much more efficiently when supported via investments within various channels of ads. Online ads may become game-changers when used appropriately, however, it takes time to adjust and get experienced. Therefore, to approach strategically, it may be beneficial to get consultation or work with a professional while beginning.

Segmentation

One of the highest crucial and most difficult actions in e-marketing strategy planning for digital advertisements is segmentation, as it is to category customers who has similar characteristics in specific ways useable within marketing, such as; age, location, gender, wealth, interests and spending habits. These categories must be planned by keeping an eye on the features offered by the tools of digital marketing. (E.g. a campaign aiming to sell cheap dental implants should be looking for less-wealthy patients, therefore not only the keywords in Google can be aimed related but also the locations focal searches are made can be purposeful. After matching the segment specifications with demographic/behavioral characteristics, next step is to plan the content and placement of the ads. As that is how the company appears on the customer's screen. Furthermore, it was once stated that the search of advertising managers for the perfect design which decreases the costs and increases the ROI rates is highly crucial [9].Therefore, marketing departments today seek for the viral ads which would attract the attention of potential customers with very low or no costs.

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Ad strategy

Like any other marketing campaign, internet-based ads can be categorized into two as push and pull. Search engine ads are to target customers seeking your type of a company, therefore ads given in are considered as pull ads; whiles Social Media ads are to push the message to a relevant audience to attract the attention of people who can be turned into potential customers. To increase the ROI rates of pull ads, focus should basically be on correct placement with correct design of interface (audiovisual content, text, buttons, etc.) to introduce your company/product as best as possible. For push marketing, having a laser-focused audience is the most crucial thing which can increase the ROI rates. As mentioned in 2014, Web 2.0 is thought as to pull marketing, in which the customer is located in the center, unlike the push marketing, where the brand/product has the focus on. Within push marketing, marketing departments aim to serve their products through mass communication channels such as social media. However, as this is a one-way, non-interactive mechanism of communication unless it allows the company's CRM collect customer data. In contrast, this is indeed a non-interactive kind of communication. Whiles in pull type of marketing the products are expected to be pulled by the customers at their own will [6].

Organic

Organic leads have differences from ads such as; breakeven point, as investments for organic leads have next to zero return rates whiles paid ads start bringing results much earlier. Mainly, there are 3 channels for the organic lead, search engine optimization, word of mouth marketing and search engine optimization. When the sources of leads are compared, SEO drives the customers with the highest lead-to-customer close rates. To begin making process of building a strategy for creating organic leads, the order is mostly as follows, get to know about the audience, explain the leads, identify the keywords aimed, observe results.

SEO (Search Engine Optimization)

As most of the lead from organic way comes through search engines, website owners better follow the search engine rules by doing Search Engine Optimization [SEO] in order to come out on the first pages and to get more organic lead. While producing contents for the website, there are some basic conditions can boost the website's SEO score such as adding keywords related to the topic and including backlinks. With a robust communication process between the content producers and website designer, SEO score of the pages can be increased significantly. Constantly, search engines, especially Google, are increasing both the number and the complexity of the regulations should be obeyed. To protect the current place or to be seen on a higher place on the search engines, it is highly recommended that the website should be checked and improved in terms of SEO periodically by an expert.

MANAGERIAL PLAN

It is the most crucial part to manage all the processes regularly and accurately to achieve the highest return rates and decrease the human capital & ads costs. Results should be monitored and converted into quantitative data in order to interpret to create business specific models. By creating models, it is made easier to measure many other kinds of data which contributes managerial planning and decision-making processes, for so, models similar to [Fig.3] should be found/created. To achieve an outstanding online identity for medical travel companies, budget distribution and organizational plan are 2 factors should be worked on.

Budget distribution

Budget distribution of digital marketing is highly dependent on the quantitative data having been collected. It takes 1-3 weeks to collect short-term results to evaluate new ideas of campaigns. However, in mid-long term, focusing only on the customer acquisition costs would make the company end up making wrong estimations as each campaign has its own audience with different return rates. To illustrate more, costs-per-click rates may be relatively higher in a location containing wealthier customers, however those customers would probably be more profitable. Therefore, a model similar to [Fig.3]can be developed/used where the existing ROI models don't satisfy the need. Besides the profit rates, it is also important which sources of information are used. Stated by Weischedel, "high priorities are assigned to the most common tasks customers perform, the most popular pages or the pages that generate the most sales" [10].

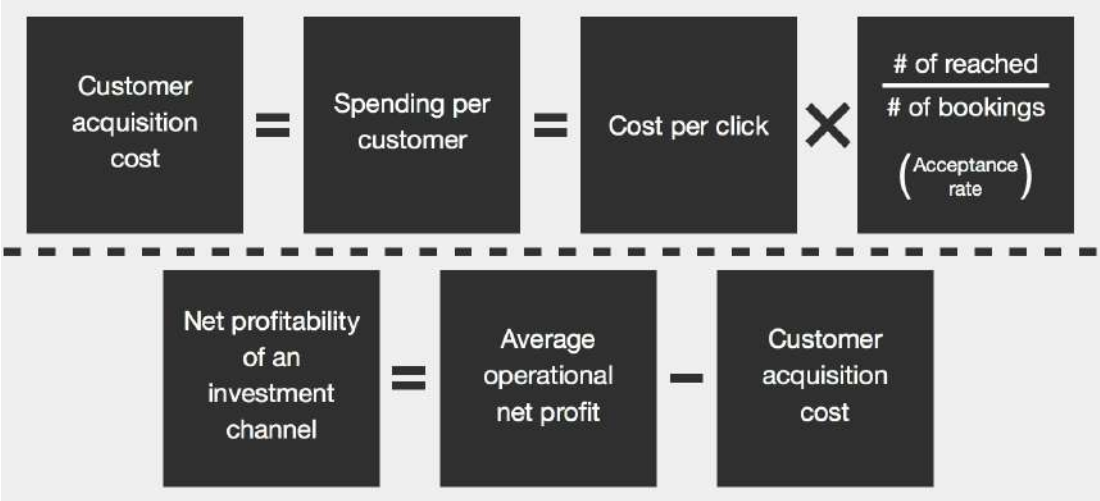

Fig. 3: An example of a model for campaign evaluation.

Organizational plan

Organizational plan is the structure of an organization which defines the relationships between employees, positions, jobs, and responsibilities. Managing the organizational planning process should start by identifying the needs and the things to be improved. After that, the decision between inner team/department and outsourcing the services should be made according to the criteria will be given next.

Inner team/Department

First and the most preferred option is hiring a team. By having an inner team/department, companies may have the pros of conducting a better communication process and having the chance of responding nimbly. The experience level and the size of the team should be selected by the current place of the company in the market in terms of the market share and the demand volume. In case the company is barely growing and does not have a big portion of the market and current demand, it may be a better idea to hire a small team and support them with 3rd party digital solutions as the human capital cost may be much higher than an app's periodic payments. A regular 3rd party app can provide detailed keyword researches, SEO auditions, ads strategy analyses, competition analyses, and much more. Also, by starting at this point, companies will have the chance of upgrading the team to a bigger and more experienced one without bearing the higher cost risk. On the other hand, if the company has a larger market share than an ordinary company in the focal market, hiring a highly experienced team is a better option as a bigger company has different customer segment and bigger demand size/variety. As a consequence of increased complexity, campaigns become harder to manage and the performance of a 3rd party app's outcome decreases dramatically.

Outsourcing

Similar with most industries, outsourcing the digital marketing in medical travel has pros and cons [Fig.4] such as having lesser control and data besides achieving professionalism and having less problems to solve. Especially for the medical travel agencies in the start-up phase, which are taking their first steps to digital marketing, outsourcing can be the option with the highest ROI. As it was exemplified 20 years ago, "An automotive company, for example, chose to outsource 100% of its digital marketing activities to its advertising agency. Its rationale was to treat digital marketing as completely separate from its in-house activities since there were no permanent staff with skills in that area, and that it was important to get some experience quickly." [12]. For some, investing in outsourcing digital ads may look like wasting the budget unnecessarily. However, when ROI rates of the options are compared; working with a professional agency may be more beneficial for the company especially in short to mid term. Therefore, the ROI rates and pros & cons [Fig.4] should be taken into consideration not only by looking at the conversion rates of the ads; instead, to evaluate the decision-making possibilities better, a more flexible ROI calculation must be made in order to come up with a model to decide better on small investments [11].However, in some cases, if an inner team of experienced people can be formed, probably in long-term this would bring not only a higher ROI, but also more ideas how to use the alternative techniques brought by digital marketing technologies.

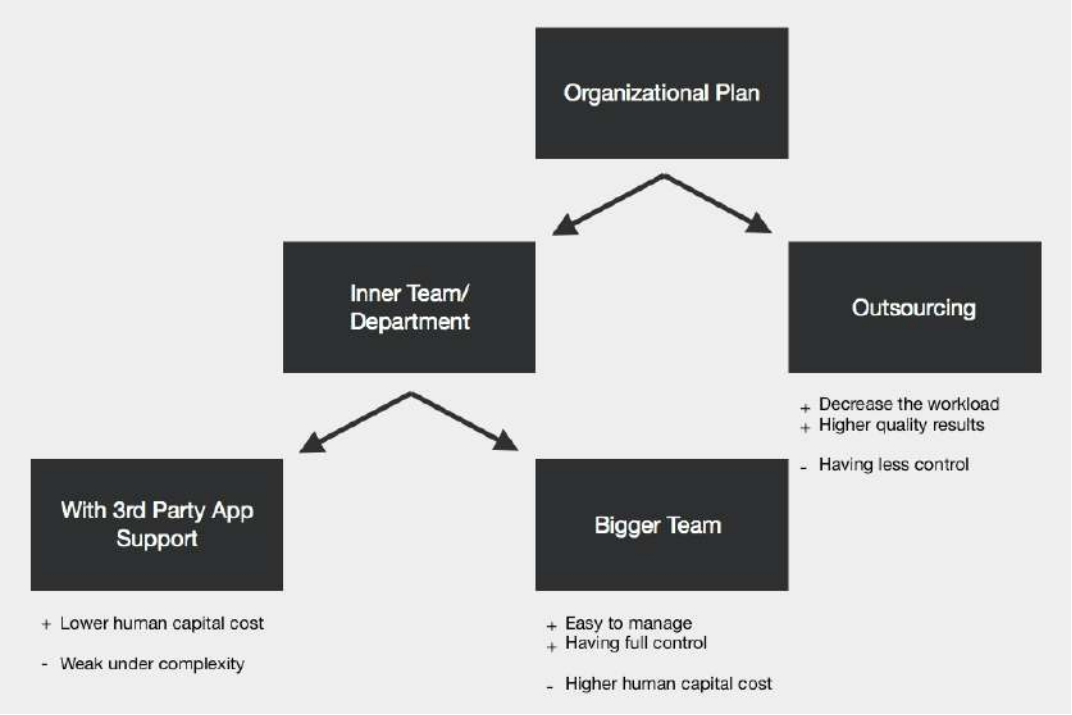

Fig. 4: Organizational plan options with pros & cons.

CONCLUSION

The study provides a step-by-step guide for medical travel agencies in the start-up phase willing to increase their online reputation. Within the information, examples and charts provided, the study will assist the managers of such companies or their founders: entrepreneurs. According to the researches and experiences included above, requirements of a well-planned online existence strategy in the medical tourism sector or any other markets are matched with the optimal solutions. All these were covered within 3 separate titles; "Online Existence", "Reaching to Customers" and "Managerial Plan". Hence, medical travel agencies willing to be known online should plan their strategy well by designing the user experience depending on the business style they have and take the necessary steps by looking at so.

CONFLICT OF INTEREST
Authors declare no conflict of interest.

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ARTICLE

PROCESS IMPROVEMENT IN A RADIOLOGY DEPARTMENT WITH VALUE STREAM MAPPING AND ITS LINKAGE TO INDUSTRY 4.0

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ABSTRACT

Background: *The current state of the hospitals' departments can be provided by some lean management tools. With the help of the value stream mapping, the big picture of a whole process can be seen. This picture shows every step that the patient will follow and it also tells about the cycle time for each service.* ***Methods:*** *The data storage system is very insufficient so that data are collected from hospital staff and by personal observations. A lean management tool, value stream mapping is used to see the general view of the radiology department with its problems at a glance. Data and the map is used as a guide to conduct a quality house to make a prioritization between the problems, to decide which one to solve firstly, of patients at the hospital.* ***Results:*** *Problems of the radiology department related to mammography and ultrasound and suggestions to these problems according to the industry 4.0 linkage.* ***Conclusions:*** *For current situation, new technological mammography and ultrasound devices are needed to increase the level of patient treatment at the same time and to decrease waiting times. The IoT will lead connecting every machine together that means sending results of a patient will be done simultaneously. Similar to the future state map, writing and giving a report to a patient will not take any time so that patient satisfaction will increase.*

KEY WORDS
Healthcare systems, lean thinking, process improvement, value stream mapping, industry 4.0.

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INTRODUCTION

Today quality definition is totally turned out to satisfy customers on time. This goal can be reached by some calculations in a production line but it is more difficult for a service sector. Especially in healthcare systems, it is more important to give a high-quality service to the patients. When the human life is considered, it is vital to start the treatment quickly. Waiting is the biggest problem at the hospital, which increases the risk of exacerbation of the disease. Even at the beginning of the healthcare system, patients try to get appointment from the hospital and they wait for long time periods, sometimes for months, to see the doctor.

These kind of delays leads to the integration of lean management and healthcare systems. Lean management aims to eliminate actions which do not add any value to the process that are defined as "waste". Elimination of non-value-added steps, shortens the lead time of the process which means to reach customer more quickly. The current state of the hospitals' departments can be provided by some lean management tools. With the help of the value stream mapping, the big picture of a whole process can be seen. This picture shows every step that the patient will follow and it also tells about the cycle time for each service. If any of the service steps is not necessary, it is tried to be eliminated such as walking between too many doors, waiting for the reports, waiting for registration etc.

Non-value-added activities' elimination is not the only thing that should be considered. Patients' satisfaction is also important and it should be checked if they want anything according to the system and the hospital as a building. The way to convert customers' needs to real developments is to use "House of Quality" (HOQ) which is a tool for quality function deployment (QFD). Voice of customer leads to technical properties of the thing that can be either a product or a service, and new product / service development will be the result.

The needs of patients are very important to draw the future state map of the hospital's department. Both current state map and HOQ will help to conduct future state map of the value stream. In this study, data is taken from the article which gives details about the radiology department's current situation at Şişli Hamidiye Etfal Hospital in Istanbul, Turkey [1]. The radiology department is considered with its mammography and ultrasound units. The purpose of this paper is to improve the mammography and ultrasound screening processes to increase the healthcare system quality and patients' pleasantness while decreasing costs.

After the introduction part, lean management and lean in healthcare topics will be covered under literature review. In the third part, methodology will be explained and then current state of the radiology department will be mentioned. Industry 4.0 linkage of process improvement will be studied at the fifth part and finally a future state map will be shown before the conclusion part.

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LITERATURE REVIEW

Lean management

Lean Manufacturing, which is also named as "Toyota Production System (TPS)" was a new process-driven production system for the industry, founded by Japanese leaders [2]. The main aim of lean manufacturing is to get rid of the "waste" while increasing the quality of the product [3]. Waste types can be classified in eight different ways: producing more than the need, inventory, defects, waiting, transportation, extra motions, non-value-added activities and the unused human ability. These waste cost nearly 95% of the whole production cost which is mentioned by Taiichi Ohno who is one of the leaders of TPS [4]. Lean principles mainly aim to make a sustainable production line while eliminating non-value-added activities. This line has to work with customer orders which means a pull system [3].

In August 1997, a non-profit organization "Lean Enterprise Institute, Inc." was founded by James P. Womack. He aimed to explain lean thinking in accordance with the Toyota system which is being used by many different sectors spread wide [5]. The Lean Enterprise Institute website gives detailed information about lean principles which is summarized in [Fig. 1].

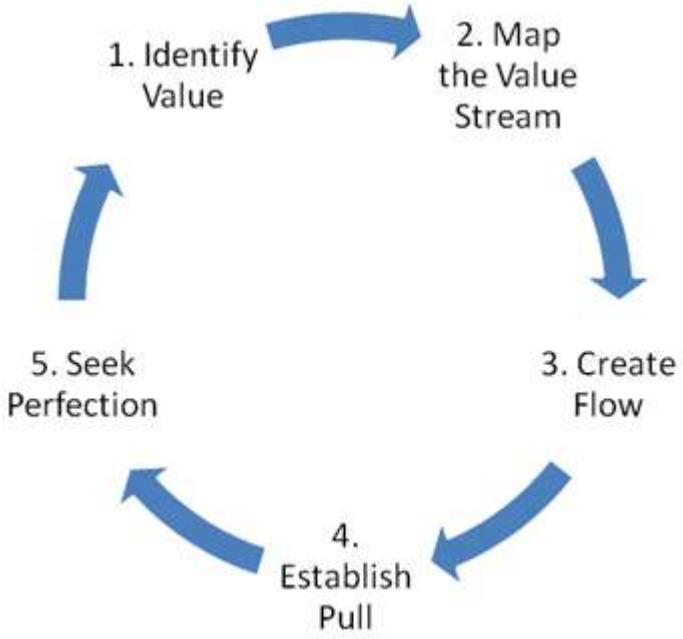

Fig. 1: Lean principles. (https://www.lean.org/WhatsLean/Principles.cfm, retrieved 05.03.2018).

Not only in manufacturing but also service industry uses lean principles in spite of application of mentioned ones are certainly different. The difference is that many service areas works with pull system, which means the customers' needs trigger the production of the service. If the system has problems in terms of the process, then waiting periods will be longer [6].

Lean in healthcare

In a production line, lean manufacturing aims to create a high-quality product and an on-time shipment to the customer. In Canada, these lean principles are concerned for healthcare systems because of the excess patient amount [7]. Recovery of the patient is the total of the value created in the medical service. For this reason, as mentioned for production line, also in healthcare sector, the process has to be customer-based, that means patient-based at a hospital [8].

In a healthcare system, to reach a "perfect" medical experience, delays, waiting times in a queue, unnecessary repeating actions, and false applications should be eliminated or at least minimized. When lean principles are adapted to health care systems to create value, some issues have to be considered such as patients, taxpayers and service providers' equality and the legal issues for costing while reaching the required pleasant level for patients. Even tough every process in a production line is known by its standards, in a service line especially at a hospital, patients' road is not clear due to different examination results. This uncertainty causes more complicated systems to be analyzed [9].

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Waste definition differs from sector to sector so that when health care systems are considered, mostly documentation causes “waste”. Also, the whole process flows and the hardware of the hospital can yield non-value-added activities [10].

MATERIALS AND METHODS

Value stream mapping

Implementing lean principles starts with the analysis of current situation to classify value added and non-value-added activities. Value stream mapping is one of the most efficient way to do this classification. The map shows the whole process of the production or service line with symbols. Its minimal structure is mainly related to “lean thinking”. The process drawn in the value stream map starts from the beginning that raw materials come from suppliers and ends at the shipping department. The expert which draws the map, follows both the production steps and information flow at a random time and captures that moment. This map is called “current state map” [11].

Current state map shows the bottlenecks on a one picture. With lean principles, these problems which are classified as non-value-added activities, should be eliminated or improved. After eliminating those “waste” improvement areas are shown in “future state map” [12].

Current State of the radiology department

The current state of the radiology department of Şişli Etfal Hospital, is visualized by the value stream map. This method captures a random moment to see the value added and non-value-added activities on a single picture. Cycle times of the related processes can be seen on the current state map [Fig.2].

The timeline shows both value added and non-value-added activities’ durations. Bottom lines between processes shows non-value-added activities, mostly waiting activity for the patient. The biggest bottleneck is waiting for the mammography appointment date, the report and the ultrasound appointment date. These durations are close to each other which is 3-4 days in average.

The value-added activities are only presents the steps to get the result from the doctor in the end. This time is totally 67.3 minutes, nearly 1 hour. But the whole process continues totally for 17367.95 minutes, nearly 12 days. This big difference is caused by the “waste” which decreases patients’ satisfaction. The house of quality will help to understand which problem to focus and improve firstly.

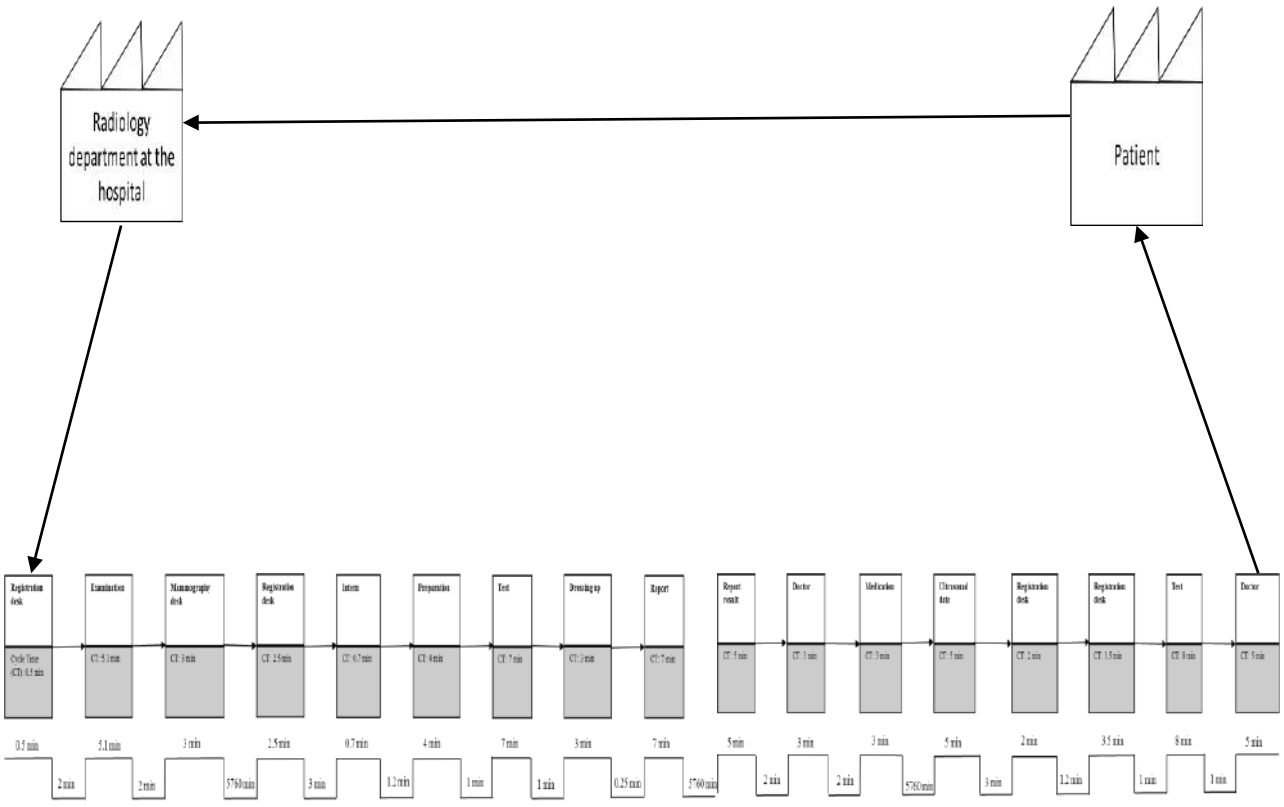

Fig.2: Current State Map.

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Future State of the radiology department

Improvement areas are shown in future map [Fig. 3]. As it is seen, total lead time of the patients' road, which starts from the beginning of the radiation department and ends after the doctors' reporting, decreased nearly 9 days which means a big improvement. As it is seen from the future map, preparation, test, dressing up, report and report result process cycle times are decreased by some technological and physical changes in the hospital. With more than one dressing room, patients will not have to wait for other patients to enter the mammography room. Another improvement area is technologically developed computers and systems. With the simultaneous voice transformers doctor can dictate the result and the nurse can directly take out the report. After the improvement, maximum one day later, the report can be delivered to the patient. Waiting a mammography result is nearly 4 days at the current situation that means extending the treatment process.

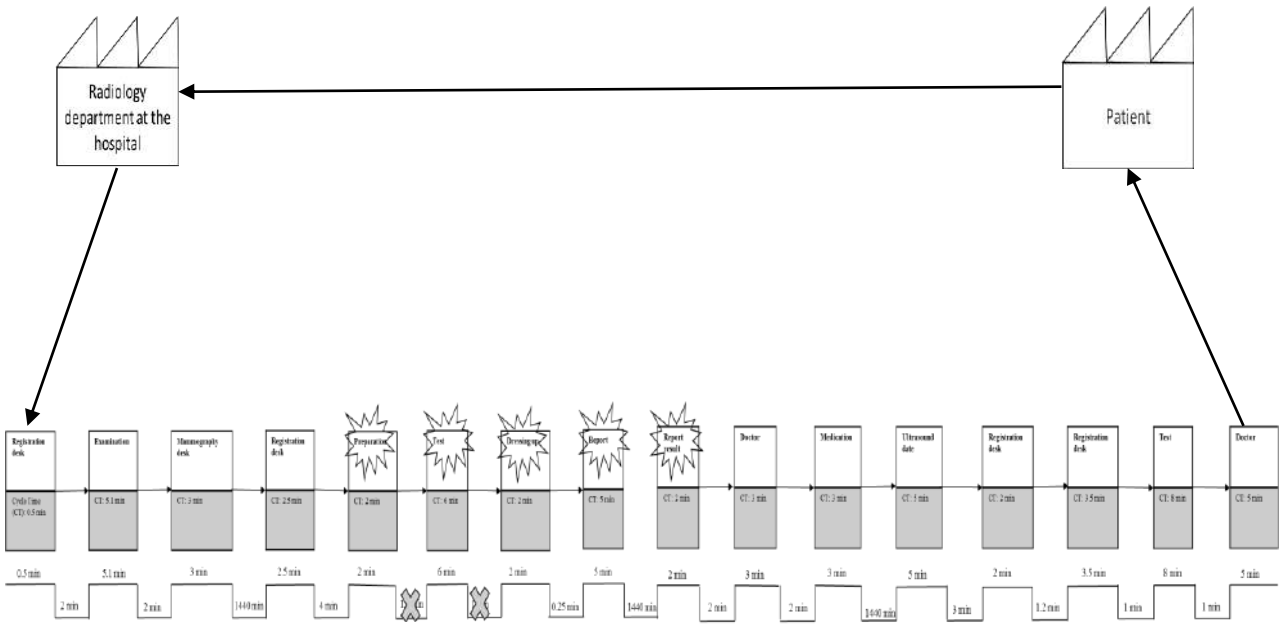

Fig.3: Future state map.

With the correct arrangement of appointments and the required test plan, patients will come on time and will not wait for long queues. In front of the mammography and ultrasound rooms there may be electronic screens to show the coming appointment. This will also improve satisfaction at a less crowded hospital isle.

Linkage of the process improvement of radiology department to industry 4.0

Traditional changes about data collection in manual mode made differences by the large adoption of IoT (Internet of Things). Especially, parameters of the production process can be recorded in various and automatically in a way of timely manner. It can be remarked that traditional industrial production only communicates with M2M technology, but IoT is able to make perfect connections between people, machines and physical objects [17].

Exchanging data and information, any technological devices in the Internet of Things make possible to reach other devices around the world at high speed. Not only the situation of individual devices but also the devices around each other can be reached by up-to-date information in minutes. The physical distances are not important to monitor or operate technology infrastructure. Optimal coordination and controlling are enabled to understand and obtain a large variety of complex technological devices [18]

In a general word, computers, tablets, intelligent devices make enable to connect to internet. Now, it is clear that even healthcare devices such as heart pressure watches, body temperature devices, which are advanced and intelligent devices, can be connected to internet and the information in these devices can be incessantly transferred. Healthcare is just applicable area of IoT alongside smart cities, smart traffic control and weather monitoring [19].

Considering that IoT, the leading time and processing time can be measured by the applications of IoT. As an example, the queue time in a mammography department of any hospital can be optimized and industry

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4.0 makes possible to have an optimized sequencing and shortened queue time which increase efficiency in a technological way. The screenings will aid to shorten waiting time and will facilitate processing in the indicated department. The process improvement, which is indicated by using Value Stream Map as indicated in [Fig. 4], is definitely facilitated by the applications of IoT and Industry 4.0 in the 21st century.

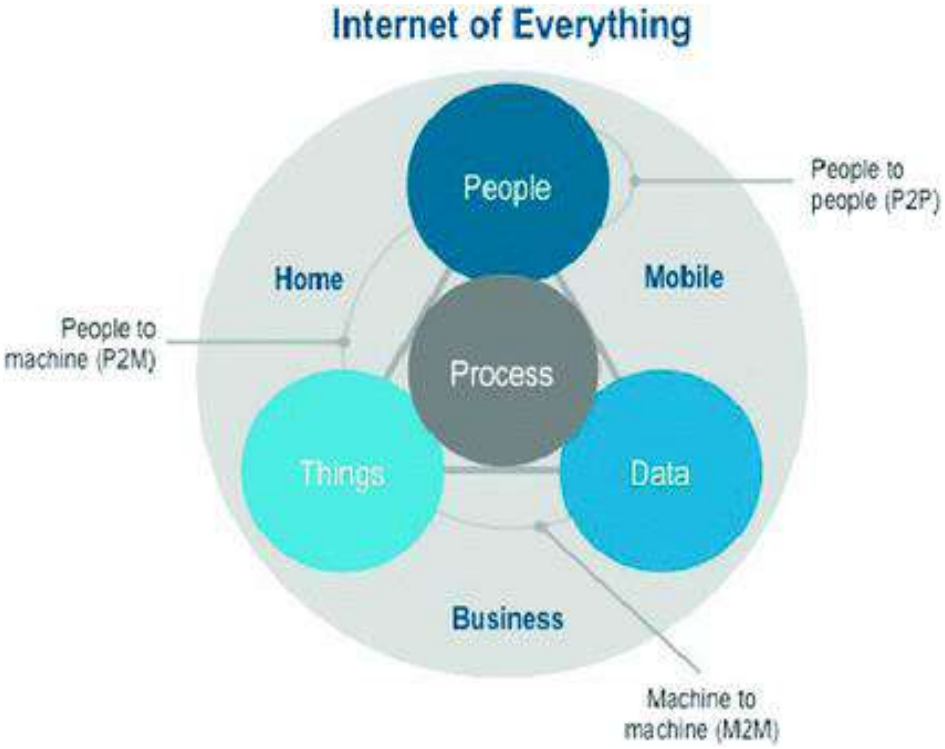

Fig.4: Internet of things (IoT) coverage (19).

CONCLUSION

For current situation, new technological mammography and ultrasound devices are needed to increase the level of patient treatment at the same time and to decrease waiting times. The IoT will lead connecting every machine together that means sending results of a patient will be done simultaneously. Similar to the future state map, writing and giving a report to a patient will not take any time so that patient satisfaction will increase.

Another IoT application can be connected directly with a healthcare system mobile application which will connect with the new appointment screens. A reminder will notify the patient from her mobile phone so that they will not have to wait at the corridors of the hospital.

All in all, an improved value stream map is created which eliminates non-value added processes of the current flowchart. In consideration of all these outcomes, it is suggested for the hospital to apply these improved suggestions which are further explained and aligned with lean application methods.

For further studies, with the discussions with the doctors and planners at the hospital, it can be searched if scanning patient with ultrasound and mammography in the same day may be possible or not. The personnel and technological capacity should be clearly defined to make a detailed plan. With the help of new industry 4.0 applications it would be more easy and effective to reach a high level of patient satisfaction and a high level of healthcare system quality.

CONFLICT OF INTEREST
None

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ARTICLE

BUILDING HOSPITAL BALANCED SCORECARD BY USING DECISION SUPPORT APPROACH

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ABSTRACT

Background: *The Balanced Scorecard (BSC) is one of the most common applications of performance management in every type of organization all over the world. The literature studies reveal that there is an obvious lack of studies which focus on integrated approach for balanced scorecard stages. The aim of this study is to develop a new decision support framework for balanced scorecard in hospitals.* ***Methods:*** *An integrated hospital BSC approach is developed from vision to action as a whole. The approach including 10 stages is developed for hospitals, originally. The new decision support system framework helps to the managers of hospitals to design balanced scorecard effectively. Some hospitals in Turkey are visited to obtain necessary information. The hospitals with top management's commitment are selected.* ***Results and Conclusions:*** *The paper finds that an integrated approach should be applied for the implementation of balanced scorecard and expert knowledge is required for every stage of balanced scorecard to support hospital managers. The model gives recommendation for every stage of balanced scorecard and it is applied in a private hospital.*

KEY WORDS
Balanced Scorecard; Decision Support; Hospital; Healthcare Management.

INTRODUCTION

The Balanced Scorecard (BSC) is one of the most common applications of performance management in every type of organization (private sector, non-profit organizations, and government) all over the world. It is used to increase the performance of a company and the employees by starting from vision, strategies and other long term concepts. BSC enables management to execute their strategies. ERP systems focus on integrating different business functions and departments in an efficient manner. While BSC uses the information derived from Enterprise Resource Planning (ERP) systems to focus the strategies, goals, objectives, and performance. The balanced scorecard is a tool that can help translate visions and strategies into an integrated set of performance and action. Kaplan and Norton [1] introduced the balanced scorecard concept as a strategic performance management system. A strategic planning study such as balanced scorecard is very useful from vision to action. Kaplan and Norton [2] state that ''the balanced scorecard translates an organization's mission, vision and strategy into a comprehensive set of performance measures and provides the framework for strategic measurement and management". The balanced scorecard concept measures organizational performance across four balanced perspectives: financial perspective, customer perspective, internal business perspective, and learning and growth perspective. They state that balanced scorecard tells you the knowledge, skills and systems that your employees will need (learning and growth perspective) to innovate and build the right strategic capabilities and efficiencies (internal processes perspective) that deliver specific value to the market (customer perspective) which will eventually lead to higher shareholder value (financial perspective) [Fig.1].

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Bisbe and Barrubés [3] studied some of the contributions, dilemmas, and limitations of Balanced Scorecards in health care organizations. They prepared a case study, formed strategy maps, but they don't emphasize the relation between strategy maps and Key Performans Indicators (KPI). Chang et al. [4] assessed both direct and indirect outcomes of the implementation of Balanced Scorecard in a hospital in Taiwan since its inception in 2001. MMH is the first hospital in Taiwan to implement the Balanced Scorecard fully for the entire organization, not just for a specific department. Cowan et al [5] reviewed the literature about competence in nursing practice. Cebeci [6] proposed a fuzzy AHP-based decision support system for selecting ERP systems by using balanced scorecard and its case study was applied in a textile company. A BSC study needs ERP infrastructure. Huang [7] suggests a knowledge-based system for strategic planning including balanced scorecard. It is important to select, manage and balance the right Key Performance Indicators (KPI) among thousands that can be produced by ERP systems for every management level and units. Companies define their vision, strategies and goals at top management level, but they cannot apply deployment at medium or lower level management and units. Almost none of the papers applied SWOT (Strength, Weakness, Opportunities, Threats) analysis. Some existing papers focus only few stages of balanced scorecard. This study helps to managers an integrated implementation of balanced scorecard by defining 10 stages originally.

Managers need expert knowledge to build an effective performance management system and BSC in every stage and they ask a lot of questions such as:

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How to define a shared vision?
How to apply SWOT analysis?
Which strategies are important for my sector and my organization?
How to apply Balanced Scorecard in hospital sector?
How many strategies are necessary for my organization?
How to form strategy maps?

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Which Key Performance Indicators (KPI) are more important for my organization?
What is the formula of every Key Performance Indicator?
How many objectives are necessary at hospital level?
How many objectives are necessary at unit level?
How many objectives are necessary at unit manager level?

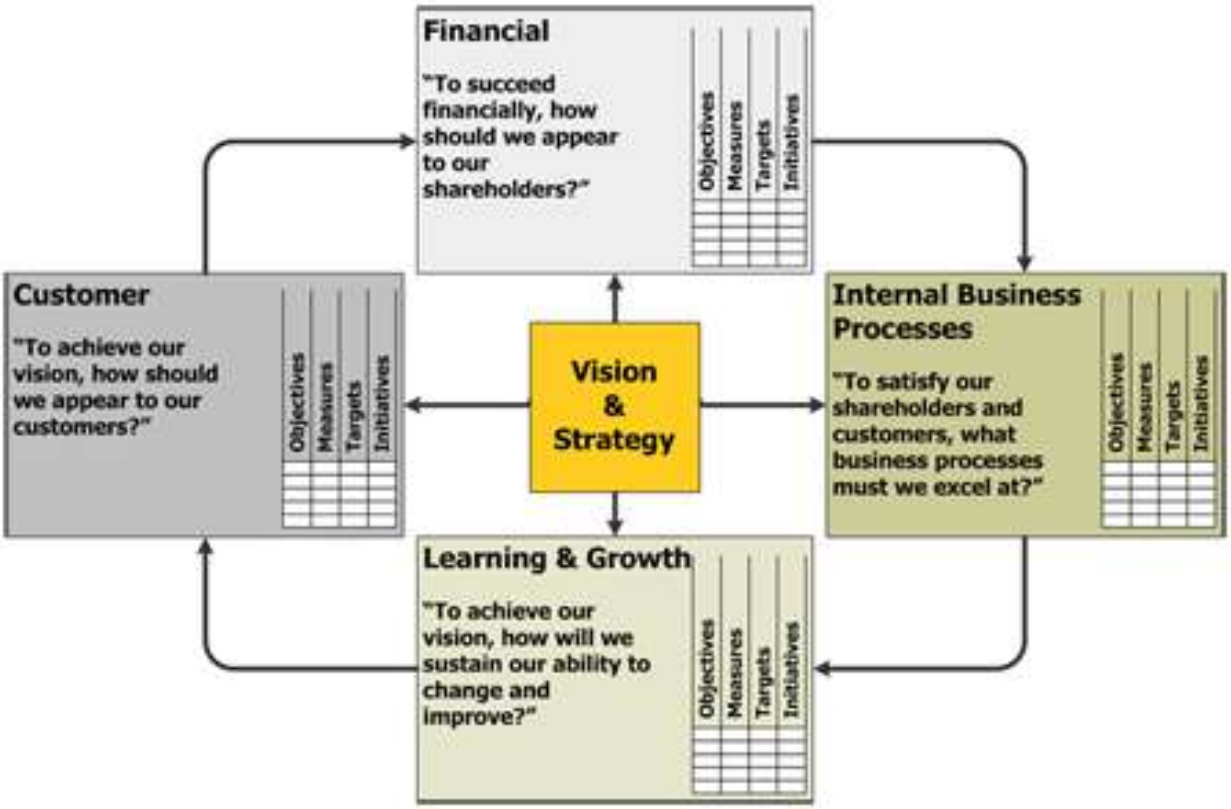

Fig. 1: The structure of Balanced Scorecard developed by Kaplan and Norton.

All these questions and more need expert knowledge. One of the objectives of this study is to answer these important questions by developing a framework of balanced scorecard decision support system for the hospitals. Another objective is to help a user who wants to build a balanced scorecard by giving some suggestions and recommendations when analyzing the necessary data derived generally from ERP system of the organization.

Scientific studies related balanced scorecard focus some parts of balanced scorecard, in general. However, balanced scorecard concept needs to be implemented from vision to action and operational level.
The rest of the paper is organized as follows:

The developed BSC decision support framework for hospitals are explained.
A Case Study from a Turkish Hospital is added to understand more clearly the BSC, A discussion section and finally conclusion section including lessons learned and future study.

MATERIALS AND METHODS

In this study, an integrated approach is developed from vision to action as a whole.

The developed balanced scorecard decision support framework for hospitals

The developed system aims to manage the stages of building a balanced scorecard for hospitals. The conceptual framework of the developed methodology by the author is presented as stages.
Stage 1: Define shared vision statement by involving all employees

Most of the Hospitals in Turkey have no shared and clear vision statement and long-range planning, global crisis and the changes affect them too much.

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BS-DSS suggests: Interdisciplinary workshops are needed to define shared vision clearly. If possible, invite consultants and external sector experts to the workshops and meetings.
The vision should have a future picture of 8 years later, at least.

Stage 2: Prepare a SWOT Analysis document related vision statement and Hospital industry.

BS-DSS suggests: SWOT (Strength, Weaknesses, Opportunities and Threats) Analysis should focus the shared vision statement so that the strategies of hospital can be determined.
You may prepare a SWOT Matrix both for your hospital and your competitor(s) in the same table to benchmark and for other reasons.

Stage 3: Define strategies by means of SWOT Analysis

BS-DSS suggests: Consider related topics for your hospital as follows (if related):
Big Data, Quality Management Systems such as JCI, ISO 9001, Traceability.
Define 4-6 strategies (the ways to achieve the shared vision) as default. If you select more than 6 strategies, it is difficult to focus them. If you select less than 4 strategies, it is difficult to realize the shared vision.

Stage 4: Draw strategy maps to link cause and effects

Most people have little information about strategy maps.
Kaplan and Norton [8] explain strategy maps as follows:
Strategy maps show the cause-and-effect links by which specific improvements create desired outcomes—for example, how faster process-cycle times and enhanced employee capabilities will increase retention of customers and thus increase a company's revenues.
From a larger perspective, strategy maps show how an organization will convert its initiatives and resources—including intangible assets such as corporate culture and employee knowledge—into tangible outcomes.

BS-DSS suggests: Select KPIs from strategy maps so that you can deploy your objectives easily. Derive KPIs and dashboards as much as from your ERP system to get results faster. Stage 5: Develop Performance Measures for Strategic Objectives, Key Performance Indicators and Targets

BS-DSS suggests: Determine balanced KPIs. It means not only financial KPIs, but also customer perspective, internal business processes perspective and learning & growth perspective.
Let KPIs be S.M.A.R.T.;
(Specific – target a specific area for improvement.
Measurable – quantify or at least suggest an indicator of progress.
Assignable – specify who will do it. Or Achievable.
Realistic – state what results can realistically be achieved, given available resources.
Time-related – specify when the result(s) can be achieved.
Define approximately 15 KPIs at hospital level.
Use necessary simulation techniques to understand the nature of important processes and their KPIs.

Stage 6: Start Strategic Projects

BS-DSS suggests: Use Project Management tools and software to get satisfied results.

Stage 7: Prepare the formula of every KPI and Determine How to measure KPIs

BS-DSS suggests: Get KPIs from ERP system as much as possible, then you will have results automatically.
Form important and value-added KPIs.
For example, a conventional "in-time delivery" KPI such as medicine, is formulated as follows:

Percentage of in time delivery = 100 * in-time-deliveries / total deliveries.

If the quantities of delivered products are different
Instead, we may use the formula of KPI as follows:

Rate of in time delivery = 100 * (quantities of in-time-deliveries / quantities of total deliveries).

Stage 8: Determine alarm and goal value of targets

BS-DSS suggests: Assign last period's value as standard alarm value.
Assign 75 percent of goal value for project type targets. Because deviation is big for project type targets.

Stage 9: Form action plans to achieve targets

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BS-DSS suggests: Use P-D-C-A Kaizen (Continuous Improvement) methodology of Total Quality Management philosophy for Stage 9 and 10.

Stage 10: Compare actual results to targets, Revise target values and actions according to results.

BS-DSS suggests: Go to the necessary stages and manage your system.

A hospital case study in Turkey

Turkey has a population of 76 million people and is growing with rising income levels.
Organizations are continuously looking for the new ways to improve their performance and stay competitive in their markets.

Some private sector hospitals are visited and studied their processes carefully. A hospital (we call "Hospital X") was chosen to apply this study because of top management's commitment.

Stage 1: Define shared vision statement by involving all employees

Hospital X organized a meeting and all employees including doctors are participated. They prepared a clear vision statement together. The vision was determined by using a Balanced Scorecard project. A management consultant managed the Balanced Scorecard project and the top management supported this strategic management application. The vision, mission, strategies, perspectives and Key Performance Indicators are determined at the meetings participating managers from all departments including top management.

Hospital X's shared vision statement is "to become one of the best hospitals in south east Europe, and Middle East region."

Stage 2: Prepare a SWOT Analysis document related vision statement and Health industry.
Hospital X prepared a SWOT Analysis document related vision statement about the Strengths, Weaknesses, Opportunities and Threats of the hospital to clarify important strategy fields.

Stage 3: Define strategies by means of SWOT Analysis:

After a SWOT Analysis (Strengths, Weaknesses, Opportunities, and Threats), strategies are determined:
Decreasing costs by using six sigma projects for TQM and excellence.
Increasing the image by using and developing innovative service applications.
Using new technologies efficiently.
Sustaining the loyalty of the patients, their families and the personnel.

The management of Hospital X decided to define just 4 strategies to focus.

Stage 4: Draw strategy maps to link cause and effects

Hospital X prepared a strategy map for the strategy "Decreasing costs by using six sigma projects".

Stage 5: Develop Performance Measures for Strategic Objectives, Key Performance Indicators and Targets

Hospital X will decide to define the numbers of SMART KPIs at hospital level.
Some considered KPIs are

- Number of notified adverse events
- Mean time [in days] on waiting list for surgery
- Average skills matrix point and etc.

Stage 6: Start Strategic Projects
Hospital X decided to start a Six Sigma Project supported by a six sigma consultant and the author of this paper. They decided to use Minitab statistics software by for analyzing operations. The six sigma project increases the level of operational excellence.

Stages 7, 8, 9, and 10 will be analyzed according to the earlier stages' outputs.
Hospital X signed a contract to add balanced scorecard module with their ERP software company to customize the software.

DISCUSSION

The information how to apply a balanced scorecard methodology is vague and distributed in the literature and industry. Besides, the implementation of balanced scorecard in hospitals is not well defined from vision into the action. Some existing papers focus only few stages of balanced scorecard. This study helps to managers an integrated implementation of balanced scorecard by defining 10 stages originally. It has also expert knowledge for every stage to support managers. A lot of companies define approximately 100

KPIs or more, while the approach recommends 15 KPIs at hospital level according to expert knowledge by Norton and Kaplan. Therefore, this approach prevents the management from the problem of too much KPI defining, applying, measuring, controlling, and etc. Similarly, the approach suggests alarm value as default value (for example: "Select last period's value as default one".), target values to the managers. Another example is the number of strategies: Too much strategies yield the problem of focusing, whereas few strategies makes difficult to achieve the firm's shared vision.
How to form strategy maps and obtain KPIs are explained.

CONCLUSION

In this study, the problem of the effective implementation of balanced scorecard in hospitals has been analyzed by using decision support system approach and used in health sector. A new decision support framework including 10 stages of balanced scorecard are developed originally:

Stage 1: Define shared vision statement by involving all employees
Stage 2: Prepare a SWOT Analysis document related vision statement and Health industry.
Stage 3: Define strategies by means of SWOT Analysis
Stage 4: Draw strategy maps to link cause and effects
Stage 5: Develop Performance Measures for Strategic Objectives, Key Performance Indicators and Targets
Stage 6: Start Strategic Projects
Stage 7: Prepare the formula of every KPI and Determine How to measure KPIs
Stage 8: Determine alarm and goal value of targets
Stage 9: Form action plans to achieve targets
Stage 10: Compare actual results to targets, Revise target values and actions according to results.

The benefits of this study for the hospital:

- Clear and shared vision with employees
- Well defined strategy
- Better image
- Increased patient satisfaction

The developed decision support system framework has recommendations for every stage of balanced scorecard. The necessary expert knowledge is derived from related literature, hospital experts and the writer's own experience.

Balanced scorecard systems have a vital role in organizations to realize from their vision and strategies into the action.

This study shows that the developed new decision support system framework helps managers to apply balanced scorecard in hospitals, effectively. In this study, the focused strategy in case study is "decreasing costs by using six sigma projects". The six sigma project increases the level of operational excellence, also.

Strategic planners can use the methodology when attempting to identify strategic issues.
The presented methodology is flexible and can be used for other sectors with some sector specific characteristics changes. The lessons from this hospital case in Turkey or other applications can be added into the knowledgebase of the decision support system. An example of lessons learned is: Defining a very good vision is not enough, it must be applied in every management level and shared by employees. Some other hospital departments can also be studied as a further study.

CONFLICT OF INTEREST
None

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ARTICLE

FORMAL COMMUNICATION CHANNELS IN A STATE HOSPITAL: A QUALITATIVE STUDY

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ABSTRACT

Background: *Tasks in healthcare settings are dispersed in time and space. Thus, task interdependence is very high in healthcare settings. In order to prove a comprehensive and error-free health service, effective information flow between employees is crucial. In this study, effectiveness of formal communication channels in a state hospital is investigated.* ***Methods:*** *A qualitative research methodology was adopted. Researchers set twelve face-to-face interview with staff and collected data.* ***Results:*** *Healthcare staff have the flexibility to choose proper communication channel while interacting with other employees from all levels of hierarchy. Formal communication channels are generally accepted as sufficient to satisfy information needs of employees. The staff do not need to search for information from informal channels. Some staff have concerns about their reports to top management. Top management sometimes fails to provide feedback, which may also convey the message that top management pays attention to information flow from the employees.* ***Conclusions:*** *Face-to-face communication is the most efficient way of communicating in healthcare settings. Mediums, which are capable of providing similar communication experience with face-to-face communication, have more chance to be adopted. Written communication tools need to be supported as they cover some deficiencies of verbal communication such as knowledge accumulation.*

KEY WORDS
Organizational communication; ICT; HIS; Communication Channels

INTRODUCTION

In the simplest form, "communication" is defined as the transmission of information between any sender and receiver in order to reduce uncertainty [1, 2]. If the sender is very sure that the receiver has fully understood the message, communication is not necessary. However, this is a hypothetical situation and it does not happen usually [2]. Therefore, communication is an inevitable component of societies.

Staying away from society seems to be a condition of not being involved in communication. Yet it is not that simple. People have more requirements than they could satisfy by themselves. Thus, when they try to satisfy their requirements or aim to realize their goals, which are too comprehensive to grasp alone, they create organizations. Although the division of work allows people to actualize their goals, an effective information flow among members of organizations is also necessary as a critical success factor [3].Communication increases organizational commitment and performance [4]. Competitive advantages originated from effective communication advance as the quality of information-sharing improves [1]. Thus, people have been searching for effective ways of communication for centuries and invented different ways of communication.

With the inventions in alternative ways of communication, the complexity of communication becomes evident. This complexity pushes people to investigate and understand the nature of communication. In literature, a number of theories, which explain the nature of communication, exist. However, advancements in information and communication technologies (ICT) keep transforming the way people communicate and reset the rules of communication. Accordingly, the nature of communication has been transformed. This transformation has effects on both personal and professional lives. As the new and easy-to-use communicational tools are introduced, old fashion and ineffcient systems are abandoned [5].
Not more than a century ago, geographically dispersed colleagues used to send letters to communicate the problems and potential solutions for their new venture [6], whereas printed letters are only used for official reasons in today's business world [7]. In an article about communication problems in hospitals, which was published in 2011, authors pointed out the problems emerging from the use of pay-telephones by nurses [8]. Currently, it is very hard to find a pay-telephone in public places in Turkey and hospitals are no exception. With the adoption of cell phones, problems that were pointed out in the mentioned article disappeared without any additional efforts. As these examples indicate, some communication problems evaporate with the advancements in ICT. Unfortunately, new technologies are not altogether problem-free though they definitely lead to improvement in communication.

In the age of digital communication, ICT melt down organizational boundaries and increases the feasibility of time-consuming projects with a large number stakeholders here and there [9], which are impossible to execute without the support of new ICT. These capabilities reshape tasks, organizations, societies, and lifestyles of people.
Communication is a broad research subject. The theme of this article is restricted to the communication means of a state hospital located in İzmir. A qualitative research is conducted to investigate the formal communication channels of the hospital. In that regard, first of all, a literature review on organizational communication will be provided, than communication in healthcare institutions and the role of information and communication technologies in healthcare will be discussed and finally the research methods and the findings of the research will be shared in the following pages.

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Organizational communication

Internal communication is the interaction among employees to execute daily operations in line with the organizational goals. As every organization has a hierarchical structure, information flows in different directions. Communication takes place between employees of the same or different hierarchal level in the organizational scheme. When it is of the different hierarchal levels, it has two directions, bottom-up and top-down. The flow of information in organizations creates a complex, internal communication network[1]. In order to manage the information flow in organizations regardless of their size or structure, organizations need to define the ways of sharing information clearly. These ways constitute "Formal Communication" paths. However, in some cases, information may not want to be shared with everyone in the organization. Especially, top management favors to keep some strategic information secret or wait for the right time to share it. In such cases, new communication paths emerge unintentionally, and information, which should be kept in secret, flows from these undefined paths. This way of information flow is named as "Informal Communication" [1]. The presence of informal communication is unavoidable in organizations and can be influential depending on the context. However, as informal communication is not a predefined way of communication, it is riskier and more error-prone [10,11].

Employees not only interact for business purposes, they also create social networks within organizations. The members of these networks discuss work-related issues as well as topics outside business subjects. When the flow of information about business issues collide with the informal means in these networks, it could strengthen the informal information flow, mislead employees, destroy satisfaction, and reduce the levels of commitment. Thus, managers should have an eye on informal information networks while strengthening formal communication channels [10,11].

The communication channels, in other words, mediums, have the potential to create different outcomes as well as the communication paths. They have different effects on both sender and receiver. They are likewise affected by social norms. For example, texting has more influence on the self-esteem of the sender than verbal communication channels [12]. Another interesting example emerges in cases where multiple messages are conveyed to a receiver through different channels. In such cases, social norms determine which message would get attention first. As an example to these cases, the interruptions via phone calls during face-to-face conversations could be given. People who involve in face-to-face communication usually do not react negatively in such situations, because giving priority to phone calls is an accepted norm for majority [13].

Regardless of the formal or informal communication paths, the sender uses a medium to convey his message. The medium preferred carries a message by itself apart from the content of the message. This fact is pointed by McLuhan by the statement: "Medium is the message" [14]. The chosen communication tool delivers more than a message; people also communicate with the attributes of the tool that they choose [5]. Messages, which are not supported with the behaviors in accordance with message content, would fail to reach its audience [8].

In light of the aforementioned realities of communication paths and mediums, organizations tend to create a communication culture, and a communication climate, which supports the desired communication culture within the organization. Setting communication culture is far more difficult than setting a communication climate. Basic assumptions, beliefs, and values of the employees form the culture. In contrast, it is easier to influence climate. Zaheeret. al. clarify the distinction between communication culture and communication climate as "different layers of the same phenomenon" [15]. When there is an established culture of communication, it is easier to shape the communication tool in accordance with the preferences of the employees. Employees tend to use promoted tools even if there are no written rules for communication. For instance, in organizations that promote e-mail, employees try to communicate through e-mails albeit the receiver of their message is physically close enough to set a face-to-face conversation. Moreover, employees try to use a formal, and polite language and pay extra attention to the rules of grammar while writing their e-mails [16].

Communication climate functions as a connection between employees and their organizations. Researchers studying organizational climate define organizational communication climate as either open or close. In open communication climate, employees can make suggestions, share their opinion, and complain about the problems that they have[17]. Open communication, notwithstanding the direction of communication, helps employees to feel appreciated and improves their loyalty [18]. Accordingly, it sustains organizational commitment and trust, and enhances information flow in all directions. On the contrary, close communication climate blocks information flow within the organizations [17].

Organizations, which value knowledge, try to support communication and collaboration among their employees by creating and sustaining an open communication climate. The assumptions behind IT investments is that IT systems enhance communication and collaboration among employees and expand information and knowledge management capabilities[19, 20].

When a sender targets a specific receiver, feedback mechanism ensures the sustainability of communication. Any sender wants to be sure that the targeted receiver receives his message, thus sender

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expects to get a reaction from receivers. Feedback is one of the strategies that relieves the sender, and it can be defined as the return of the same message to its initial sender after being paraphrased by the recipient [2].

In some cases, the sender shares his knowledge on an issue without targeting any defined audience group. Most known version of this way of communication is social media. In social media, shares are accessible by either a specific society or by everyone. Organizations tend to use this advantage of social media by creating enterprise social media (ESM). Unlike social media, ESM is open to employees only. Employees are encouraged to use ESM to achieve business objectives. Instead of peer-to-peer knowledge sharing, employees use ESM as a platform to ask questions to their colleagues and also to answer questions of their peers. This way of knowledge-sharing accumulates tacit knowledge, makes it available to everyone and shortens learning period [21].

Organizational communication in healthcare settings

The current business world has a tendency to use ICT to enhance communication effectiveness. However, in healthcare settings, depending exclusively on ICT is not appreciated as much as it is in other industries [22]. As the effectiveness of communication has a critical importance in healthcare services, regarding patient-physician information-sharing, patient behavior, health outcomes, and safety [23], healthcare professionals prefer to use multiple channels to reduce deficiencies emerging from communication via single channel [22].

Care in healthcare systems is distributed to different units. Yet these units are interdependent. High quality and individualized care require intense communication and knowledge-sharing among healthcare staff [2]. Therefore, health services heavily depend on fast and intense communication [24]. Accordingly, in healthcare organizations, employees do not hesitate to be in close relationship with their supervisors. They give priority to verbal communication tools and prefer to support communication with visual aids. As face-to-face communication can usually prevent underaccommodation, it is preferred as long as it is possible [8]. However, healthcare services are non-stop services. Most healthcare institutions serve for 24 hours in a day therefore use of a variety of communication mediums is unavoidable [25]. However, mediated interaction, unlike face-to-face communication, is riskier regarding the possibility of the misinterpretation of carried messages [25]. Time-lagged, insufficient and incomplete information flow is defined as the main communication problem in healthcare settings and occurs more frequently when a mediator is used [8].

Hewett, Watson, and Gallois compared how well doctors could interpret reports of their own discipline and specialty or of others. Their findings clearly demonstrate insufficiencies of doctors in interpreting the reports of different disciplines due to the terminology differences between different disciplines. In the same paper, doctors suggest repeating the examinations instead of using reports from their colleagues as a solution to underaccommodation [25].

Zaheeret. al., handled patient safety issue within a communication framework. Patient safety is a critical issue in healthcare institutions, which would create a chain of undesired consequences for both patients and healthcare staff. Active error reporting system would reduce the occurrence of errors and its impacts. Yet, the error-reporting system is also part of the communication system of healthcare settings and therefore the factors affecting the efficiency of the communication system influences the error-reporting system as well. As stated by Zaheeret. al., the perception of front-line staff in communication culture plays a significant role in the effectiveness of the error-reporting system. “Ease of Reporting”, “Norms of Openness”, and “Participative Leadership” improves the perception of patient safety by improving the collaboration among healthcare staff within healthcare settings [15].

There are other factors affecting the use of mediated communication tools in hospital settings. Popovici et al. listed these factors as “interruptions”, “issues with numeric pagers”, “lack of integrated communication tools”, “lack of awareness of consultation status”, “inefficiencies related to the paper chart”, “unintuitive user interfaces”, “mixed use of electronicand paper systems”, and “lack of up-to-date contact information” [26].

Problems in communication do not always originate from the tools [27–29]. Ergünler and Fener group these factors as “physical and technical”, “physiological and social”, and “organizational”. The physical structure of the organization, inefficiencies in the feedback mechanism, an excessive amount of information flow, hierarchical structure, management style and differences in status are organizational factors to be addressed [30].

Moreover, face-to-face communication and mediated communication should be handled as different realms of study. Managing these two ways of communication compels different knowledge, skills, abilities, and other capabilities. Thus, Schulze et al. suggest that it is very crucial to choose the employee who has proper capabilities for existing communication environment. As an example, managers should select people who can communicate via computer-mediated channels for virtual teams [31]. Thus, managers should be aware of the communication channels, which are already dominant in specific settings, and learn how to cope with problems of these channels.

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ICT in healthcare settings

ICT not only improve internal communication in healthcare but also enhance interaction with patients [32]. The potential of ICT in healthcare settings has been discussed from different perspectives. Setting an Health Information System (HIS) in healthcare organizations is usually harder than other industries as the number of stakeholders included is more, the structure of payment is more complex, and legal constraints are tighter [33]. Besides these complexities, ICT have the potential to simplify process within healthcare settings, and reduce risks by minimizing errors arising from interruptions in information flow [34, 35].

ICT convey information within organizations very fast if it is not real time. They raise the variety of communication channels by enabling a number of tools such as email, question-answer programs and synchronous communication channels. They also improve communication among colleagues. Although professionals do not perceive all of these tools equally beneficial, these tools improve communication among colleagues as long as they fit in organizational requirements and personal competencies [36].
One of the most discussed technologies used in healthcare is Electronic Medical Records (EMR). Use of EMR generally enhances the availability of medical records in terms of time and place, hinders loss of reports, simplifies patient flow, and reduces paperwork [37]. Healthcare staff criticize EMR only because they reduce face-to-face communication possibilities. As it is easier to leave a note, healthcare staff sometimes do not strive to interact directly [22].

Intranet solutions mostly come with different features to improve communication and share up-to-date information with healthcare staff. It forms the infrastructure to develop departmental websites. These websites not only serve as information sources but also as platforms to announce upcoming events [38]. It already replaced the staff newsletters [39].

The community of practice forums appear as inter-organizational knowledge sharing platforms. It assists health professionals who have limited colleague support or have to work alone. Professionals share their tacit knowledge, which they gain from their experiences. These sharings become available to everyone regardless of time and space. Moreover, they help knowledge accumulation [40].

The benefits of ICT increase as healthcare staff use IT systems regularly. Low acceptance of any IT system ends with failure [33]. Although problems in the design process of IT would emerge from both technical and non-technical sources, non-technical reasons seem to be more common and dominant [41]. The degree of utilization of any IT system depends on its ability to reflect the expectations and requirements of its users. Thus practitioners generally claim user involvement during system development [41].

Unsuccessful experiences with older technologies would sometime restrict the adoption of new systems [42]. For instance, during the use of radio pagers, messages were frequently interrupting workflow, they were usually undocumented thus available information about any event was limited with the memory capacity of staff. Although a more efficient tool was not available during this period, clearly this technology was not a perfect fit for healthcare settings [24] when compared to other advanced technologies, which support access to information from different information sources without any interruption in workflow [43].

MATERIALS AND METHODS

Data collection

Authors of this research aim to investigate the efficiency and effectiveness of formal communication channels of a state hospital by examining communication problems among healthcare professionals. The hospital under study has been serving secondary healthcare institution for ten years. It has more than 30 units with 151-bed capacity. 406 healthcare staff work in the hospital actively. The hospital gives service to nearly 6000 outpatient and 800 inpatients each month. As it can be seen, the hospital is large in scale, therefore constitutes a proper case to investigate communication problems in healthcare.
With the aforementioned aim, a qualitative research was carried out. Semi-structured, twelve face to face interviews were conducted with twelve healthcare staff from different departments; namely Operating Room, Surgical Intensive Care Unit, Internal Medicine, Orthopedics, Pulmonology, Neurology, and Pediatrics [Table 1].

Participants answered the following questions after a short introduction about this research;
- Question 1: How do you get information about the decisions of upper management?
- Question 2: Which channels do you use in order to report to upper management?
- Question 3: Which channels do you use in order to communicate with employees or managers of other units?
- Question 4: Which channels do you find more effective for communication?
- Question 5: Do you think your reports reach to top management?
- Question 6: Which channels are frequently preferred for sharing information in the hospital?

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Table 1: Profile of participants

Participants	Sex	Age	Marital status	Educational status	Profession	Total experience	Experience in the hospital
1	F	44	Married	Bachelor	Nurse	25 years	23 years
2	F	39	Married	Bachelor	Nurse	23 years	12 years
3	F	52	Married	Two-year degree	Nurse	31 years	27 years
4	F	29	Married	Bachelor	Nurse	6 years	2 years
5	F	39	Single	Bachelor	Nurse	20 years	8 years
6	F	38	Married	High school	Nurse	21 years	1 year
7	F	36	Single	High school	Data entry staff	3 years	3 years
8	M	42	Married	High school	Staff	4 years	4 years
9	M	38	Married	Two-year degree	Technician	15 years	5 years
10	F	45	Single	Two-year degree	Nurse	25 years	8 years
11	F	35	Married	Two-year degree	Nurse	16 years	10 years
12	F	35	Single	Two-year degree	Nurse	14 years	2 years

RESULTS

Participants generally indicate that they, in most cases, learn officially approved decision of the top management via the intranet. In some cases, setting a meeting with staff is another way of communicating top management decisions. The announcement system is used for operational decisions that need to be spread quickly. The telephone is commonly used communication technology to deliver the top management decisions as well. Participant 2 states that she gets informed informally: *"I mostly get information informally, and I learn official ones through intranet"*. Thus, even though people have some informal information sources, they are connected to formal channels.

For reporting to upper management, all participants prefer formal channels. Writing a petition, reporting through Patient Information Management System (PIMS), or reporting to a senior manager via face-to-face interaction, are the ways to transfer their information to upper management. In case of emergency, verbal communication tools are preferred. Participants indicate that they mainly choose face-to-face communication instead of written communication tools.

Communicating with colleagues from different units likewise leans on formal channels, yet tools used for communication depends on the particular situation, and the units. The telephone is the most favored tool, followed by face-to-face conversations. Written communication tools are used infrequently. Participant 11 claims that she uses PIMS to communicate with technical units, and for other units, she prefers telephone or face-to-face interaction. Answers of other participants support participant 11. Participant 6 summarizes it as: "*sometimes written, sometimes verbal*".

Participants have quite different preferences considering the effective ways of communication, though ten participants out of twenty mention that they favor formal channels. Only participant 2 emphasizes informal communication by saying: "*Of course informal ways are more permanent and effective*". Participant 9 does not foresee any difference between formal and informal ways and rates both ways equally important. Other participants agree that formal ways are more effective than informal ways. Most importantly, they point out the importance of using the right in compliance with the situation. For some cases, face-to-face communication is the best option. Participant 7 clearly denotes her first choice as the "*meetings that everyone attends*". Participant 4 strictly points out the significance of documentation:

"The information we receive in written form is more effective and lasting. Spoken words fly away, written words remain."(Participant 4).

Generally, participants agree that effects of written notifications have long-term consequences, thus it is more effective.

Disagreement becomes evident for question 5. Six participants believe that their reports to top management are delivered whereas two participants disbelieve. Other participants are not sure whether their reports reach to the top management. Some examples quoted from their answers are as follows;

"My reports reach only to head-nurse and do not go any forward. They are relayed only if no solution can be found" (Participant 3).
"Yes, they reach. They reach as much as the counter side can perceive them, yet they still reach" (Participant 9).
"Partially, written ones may reach" (Participant 4).
"Yes, usually" (Participant 5).

During the interviews, authors observe that the participants have some concerns about their reports reaching to the top management as they are. They cannot be sure if the whole contents of their reports are delivered to the top management although half of them connote that they believe that their reports arrive. The rest of the participants openly share their concerns.

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In general, two third of the participants specify formal channels as more frequently used communication channels while the rest identifies informal channels as commonly used channels for communication. For formal communication, written tools are preferred more frequently than verbal tools. PIMS and intranet are the two most commonly used tools for written communication. PIMS is specifically designed to support internal communication, and it is the favorite tool for some of the staff. Intranet mainly performs the dissemination of information from top management. Communication among colleagues mostly occur through telephone or face-to-face communication [Table 2].

Table 2: Summary of answers

Questions	Answers		
1	Formal: 10	Informal: 2	Both: 0
2	Formal: 12	Informal: 0	Both: 0
3	Formal: 12	Informal: 0	Both: 0
4	Formal: 10	Informal: 1	Both: 1
5	Yes:6	No:2	Partially:4
6	Formal: 8	Informal: 4	Both: 0

In sum, participants trust formal communication more than they do informal communication. They find it more reliable. The tools used for formal communication change with the direction of information flow. When information flows top-down, PIMS and intranet are effective tools. For reporting to upper management, both verbal and written ways can be preferred. Horizontal information flow occurs through verbal discussions generally.

CONCLUSIONS

There is a suitable medium for each situation; the key is to be able to find that medium. The differences among mediums are characterized by three dimensions; interactivity, channel capacity, and adaptiveness [5]. According to medium preferred, the receiver would provide feedback simultaneously, synchronously or continuously. Mediums address sense organs differently. Written messages can only be read. Verbal communication mediums deliver both message and intonation whereas face-to-face communication conveys the message, intonation, and gestures. Even if the message content is the same, each medium delivers it with different intensity. On the other hand, adaptiveness is defined as the ability to adjust message for varying receivers. Thus, senders choose the most appropriate medium to convey their messages to receivers.

Findings of this study are in line with this description of the medium. Messages send from top management are usually informative, and target at least a group of employees or the whole organization. Intranet forms an effective platform for information flow in a top-down manner. Conversely, bottom-up information flow is usually case specific and addresses an exact supervisor or a small group of top managers. Therefore, employees prefer to interact with their supervisor directly. This interaction can be either face-to-face or phone call conversation. These two mediums both enable fast feedback, and have relatively larger and flexible capacity. In case of disagreement or misunderstanding, the conversations among communicators can be extended.

In order to report to top management, employees choose to communicate in written form and do not expect a fast feedback. Some employees even do not expect a return at all, and they are not sure whether the top management receives their messages. At this point, a deficiency in communication becomes apparent. This clue is enough to believe that top management fails to sustain mutual interaction. If the belief that reports from employees are not taken into consideration by the top management becomes widespread, employees would inevitably feel under-valued. Accordingly, both the quality and the quantity of information flow from bottom-up would decrease. Top management would lose the chance to get fully informed in a timely manner.

The study had certain limitations. First, the study was conducted in a state hospital, thus findings are not generalizable. All state hospitals use the same information system infrastructure. Thus, findings demonstrate that the system is use is sufficient. Hospitals having trouble with the systems should concentrate on non-technical areas such as training, IT support etc. In this study, researchers did not have any contact with top management. Therefore, the perspective of top management is missing. In the next step, perception of top management can be targeted. The differences between employees and top management may provide more insights and improvement opportunities may be defined.

In general, it can be said that formal communication paths in the organization satisfy the communication needs. Use of alternative tools is encouraged and employees can choose any tool suitable according to their needs. Informal communication is not overvalued. Unlike earlier studies, access to the Internet and accordingly Internet resources do not appear as a problem. As mentioned previously, the high adoption rate of mobile ICT diminishes this problem and makes intranet a valuable information source. Even so the rise of ICT does not lower the value of face-to-face communication.

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Another critical issue pointed by participants is the importance of documentation. Keeping records is not only a legal obligation but also contributes to the accumulation of knowledge. Personal health records improve traceability of patients, ease availability of patient information, and form infrastructure for scientific research. Accordingly, patient information becomes available as needed without the restriction time and space. In necessary situations, these records are considered as evidence as well. Therefore, the hospital management should put more effort to improve written communication channels.

In the light of previous studies and findings of this study, authors conclude that the importance of face-to-face communication would not decrease in near future. In healthcare institutions, it is hard to compensate errors; proactiveness is more effective than reactive approaches. Nevertheless, healthcare services are distributed in healthcare facilities and the tasks of these units are interdependent. Effective communication can minimize the obstacles raising from interdependence, and face-to-face communication sets the target of effectiveness for all other mediums.

CONFLICT OF INTEREST

There is no conflict of interest.

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ARTICLE

PROCESS MINING FOR CHECK-UP PROCESS ANALYSIS

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ABSTRACT

Background: *Healthcare environment has a critical importance for several reasons. First of all, health is one of the most valuable wealth in human life. There have been many studies to develop clinical processes by optimizing resources, reducing the waiting time, increasing the patient satisfactory. In Turkey, majority of the healthcare processes are monitored, managed and improved in ad hoc, manual and labor-intensive ways. Since healthcare processes are complicated and flexible, and have huge number of data, this process management methods are insufficient and ineffective.* ***Methods:*** *In this study, we use process mining technique to analyze check-up processes. Process mining uses event logs to automatically extract information about the process. It can be seen as a missing link between data science and process science.* ***Results:*** *We examined 372 events, 732 cases, and 9 different activities in this study. Bloodletting is the mostly occurred activity. At the same time, it increases 'Patient Record' occurrence due to the dominant loop. The average duration of a check-up is 59.5 hours.* ***Conclusions:*** *Process mining techniques provides an easy to use way to success a global view of the processes. With the results of the process mining, the health professionals and managers can achieve a real view of the problems that are currently happening in the analyzed area. It also helps to improve complex processes in hospitals.*

KEY WORDS
process mining, checkup, workflow, event log, patient paths

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INTRODUCTION

Process mining has been applied in many areas such as education [1, 2], banking [3, 4], manufacturing [5], municipality [6, 7], and informatics [8, 9]. These domains have often partly structured or semi-structured processes with some exceptional behaviors. However, healthcare environments need flexible decision making and have mainly unstructured processes. Explicitly, a healthcare center is not a factory and patients are more valuable than products. Healthcare domains have a critical significance for several reasons. Health is one of the most valuable wealth in human life. Demand of medical services has increased due to aging population and improved standards of living. The number of cancer patients in Turkey has increased rapidly. Check-up as a precaution reaction has a critical significance to avoid cancer types and other types of diseases.

Check up is a kind of health screening taking into account age, hereditary structure and environmental factors. The aim of the check-up is to determine the possible diseases of a person without health problems in the early period and to take precautions. Health problems that are difficult to treat in advanced stages; it leads to a depressing process for the patient and his family. Early diagnosis and planned treatment can be life-saving, especially after a yearly health screening in people with a family history.

To optimize a process, one has to first understand the As-Is process. And this is usually far from simple, because business processes are performed by a number of people, often across different organizational units or even companies. Everybody only sees a part of the process. In majority of industrial applications, ad hoc, manual and labor-intensive ways were used to improve, monitor and analyze a healthcare process [10]. However, these methods have some limitations. The effectiveness and success of an ad hoc approach can only be measured by checking the impact on performance metrics. This impact analysis needs several months, which is not reasonable for healthcare process management. Process variations and exceptions and their root causes are critical factors that affect the process performance indicators. Capturing these factors with a tradition process management methods is not easy. Moreover, almost all practices have differences between prescribed and actual processes.

Process mining gains insight into actual healthcare processes. It can capture process variations and process exceptions. The root causes of an ineffectiveness event can be defined. In this study, we propose the application of process mining to analyze check-up processes in an oncology hospital in Turkey. The data for over 630 patient activities, extracted from the hospital information systems, were linked together and analysed to better understand the differences in the practices associated with check-up management.

RELATED WORKS

Process mining many advantages for professionals in different sectors. Process mining implementations have grown in especially healthcare environment because most healthcare processes are complex, dynamic, and multi-disciplinary. According to the study of Erdogan and Tarhan [11], process mining has rapidly grown in healthcare area.

Diagnosis and treatment processes in hospitals usually vary for each patient. The reason for the variability may be an effective tool to improve processes. Caron, Vanthienen, and Baesens [12] investigated clinical processes using past event logs to uncover variabilities. They aimed to produce positive outputs such as optimum resource usage and increasing patient satisfactory and safety. It is very important to understand real processes to reduce costs and improve quality. Montani et al. [13, 14] applied case retrieve and

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process mining techniques to stroke processes. Lin et al. [15] examined the processes of cerebral palsy patients with process mining and predicted the path of new patients with data mining methods. Yoo et al. [16] analyzed the outpatient processes in varying conditions such as environmental changes, waiting time, and the time spent for treatment. Rojas et al. [17] focused on the application of process mining and data analysis techniques to answer questions about emergency room processes that are frequently asked by emergency room experts. Badakhshan and Alibabaei [18] used three types of process mining which are discovery, conformance checking and enhancement, in emergency call services. Rebuge and Ferreira [19] developed a methodology for process mining techniques, which identified regular behavior, process variables, and exceptional medical conditions. They used sequence clustering method to compile the behavior of successive traces in the logs. The complexity of the processes makes the value stream mapping difficult in hospitals. Antonelli and Bruno [20] used process mining to draw value stream mapping. Partington et al. [21] applied process mining to measure differences in the treatment of patients with breast pain. They focused on inter-organization comparison of processes and process performances. To facilitate comparison analysis, they implemented clustering, process discovery, performance analysis and flows. Blum et al. [22] proposed a model for surgeries to automatically visualize and produce a statistical model describing the operation flow. Since the management and effectiveness of clinical processes were not studied, Overduin [23] filled this gap. He made an application in the process of cataract surgery.

In a general manner, check-up is performed for several purposes. The check-up type may change according to the patient needs. Several types such as full or partial may be used depending on the patient health condition. The main aim of the study is to discover the most followed patient paths and uncover deviations from prescribed hand-made process model.

PROCESS MINING

Process mining is a methodology that covers not only process modeling and process analysis abut also data mining and business intelligence [24]. The major goal of process mining is to discover, explore, control and develop business processes from event logs in the information systems. Process mining covers several study areas such as process discovery, comparison of the model and event log, checking of deviations, social network analysis, simulation models, forecasting and recommendations [25]. In the era of Industry 4.0, the digital world and the physical world are now intertwined. Information systems record huge amount of event logs that can be used to manage processes. Process mining uses the recorded event logs as an input to analyze the business processes.

Discovery, conformance checking, and enhancement are the types of the process mining [25]. The process discovery is the most important and popular output of a process mining study [26]. Process discovery algorithms create a process model without using any prior knowledge. Different notations such as Petri Net and BPMN describe the behavior in the event logs and represent the discovered model. There are several discovery algorithms such as alpha [27], genetic mining (De Medeiros et al., 2007), PALIA (Fernández-Llatas et al., 2010), and heuristic mining [30].

Although we will not go details of the process mining principles in this study, they are necessay to undertand how process mining works. Process mining set log-based ordering relations among activities. Disco scans all event logs. If activity *a* is followed by activity *b*, and activity *b* is never followed by activity *a*, it is assumed that there is a causal dependency between activity *a* and activity *b*.

Definition 1: Log-based ordering relations [25]: Let L be an event log over A and let $a,b \in A$.

$a >_L b$; if and only if there is a trace $\sigma = \langle t_1, t_2, t_3, ..., t_n \rangle$ and $i \in \{1,...,n-1\}$ such that $\sigma \in L$, $t_i = a$ and $t_{i+1} = b$;

$a \rightarrow_L b$; if and only if $a >_L b$ and $b \not>_L a$;

$a \#_L b$; if and only if $a \not>_L b$ and $b \not>_L a$;

$a \|_L b$; if and only if $a >_L b$ and $b >_L a$;

For example, $L = \left[\langle k,l,m,n \rangle^3, \langle k,m,l,n \rangle^2, \langle k,o,n \rangle\right]$ represents the traces in the event logs. In the event log, the order of $\langle k,l,m,n \rangle$ is counted three times. For this event log, following log-based ordering relations can be created.

$$>_L = \{(k,l),(k,m),(k,o),(l,m),(m,l),(l,n),(m,n),(o,n)\}$$

$$\rightarrow_L = \{(k,l),(k,m),(k,o),(l,n),(m,n),(o,n)\}$$

$$\#_L = \{(k,k),(k,n),(l,l),(l,o),(m,m),(m,o),(n,k),(n,n),(o,l),(o,m),(o,o)\}$$

$$\|_L = \{(l,m),(m,l)\}$$

The relation $>_L$ shows all activity pairs in a direct follows. For example, *k* is directly followed by *l* in the trace of $\langle k,l,m,n \rangle$. On the other hand, $m \not>_L n$ because *m* does not directly follow *n* in any trace. The relation $\rightarrow_L$ presents all relation activity pairs that have a causality relation. $m \rightarrow_L n$ because *c* sometimes directly follows *d* and *d* never directly follows *c*. The relation $\#_L$ refers all activity pairs that does not directly follow each other. Since *l* never follows *o* and never the other way around, therefore $l \#_L o$. The relation $\|_L$ includes parallel activity pairs. $l \|_L m$ because sometimes *b* directly follows *c* and sometimes vice versa. In other words, $b >_L c$ and $c >_L b$. A footprint matrix shows relations among activity pairs. [Table 1] represents the footprints for the event log *L*.

Table 1. Footprint of event log *L*

	k	l	m	n	o
k	$\#_L$	$\rightarrow_L$	$\rightarrow_L$	$\#_L$	$\rightarrow_L$
l	$\leftarrow_L$	$\#_L$	$\|_L$	$\rightarrow_L$	$\#_L$
m	$\leftarrow_L$	$\|_L$	$\#_L$	$\rightarrow_L$	$\#_L$
n	$\#_L$	$\leftarrow_L$	$\leftarrow_L$	$\#_L$	$\leftarrow_L$
o	$\leftarrow_L$	$\#_L$	$\#_L$	$\rightarrow_L$	$\#_L$

CASE STUDY

For this study, we gathered data from a private hospital in Istanbul. A full check-up process has several activities; MR, BT and USG in radiology department, bloodletting, EKG, lung x-ray, abdominal ultrasonography, mammography, other examinations and preparation the check-up report. According to the patients need, the check-up process may vary.

Some basic process mining terms can be explained briefly to better understand the study.
Activities: Total number of different activity types in the event log.
Events: Total number of activities in the data set.
Cases: Total number of process instances in the event log.
Attributes: Total number of columns from the dataset that have been imported.
Start and End: The range of time covered by event log from earliest to latest timestamp observed.

Data preparation

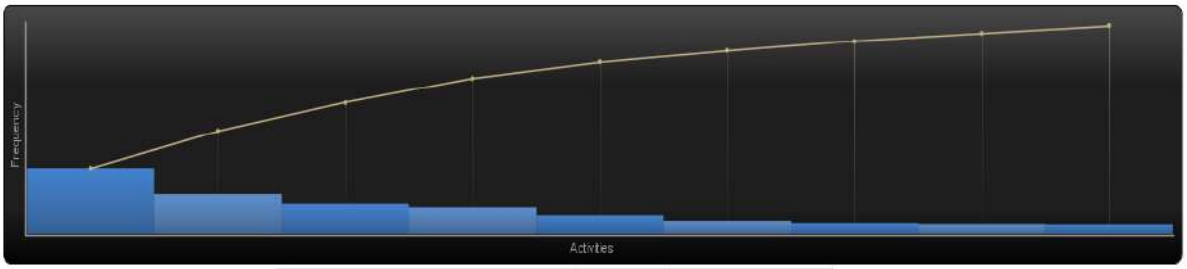
The final output in Microsoft Access was a table containing the following columns: (1) customerID, (2) activity (3) start and (4) end. Subsequently the final output from Microsoft Access was exported to a Microsoft Excel spreadsheet. From Microsoft Excel it could be directly imported in the process mining tool Disco. In the Disco import tool, the column 'customerID' was selected as the cases, the columns 'start' and 'end' as timestamps, the column 'activity' as events. Table 2 shows a sample of event logs.

Table 2. A Sample of the Event Log

CustomerID	ActivityName	Start	End
34612045	Patient Record	15.12.2017 10:01	15.12.2017 10:10
38541418	Patient Record	15.12.2017 10:07	15.12.2017 11:17
39063121	Patient Record	15.12.2017 10:09	15.12.2017 10:21
34612045	Lung X-Ray	15.12.2017 10:11	15.12.2017 10:38
33109839	Abdominal Ultrasonography	15.12.2017 10:12	15.12.2017 10:25
34612045	Patient Record	15.12.2017 10:19	15.12.2017 10:24
40271267	Bloodletting	15.12.2017 10:21	15.12.2017 10:33
39063121	Other Examinations	15.12.2017 10:21	15.12.2017 10:42
34612045	Patient Record	15.12.2017 10:01	15.12.2017 10:10
38541418	Patient Record	15.12.2017 10:07	15.12.2017 10:17

Discovery of Check-up Process and Evaluation

Log inspection was carried out in Disco. In total, the event-log contained 2372 events, 732 cases, and 9 distinct events (activities). Although basic statistics do not give results on the general view of the patient pathways, they are useful to see some data-centric results. Figure 1 shows the activity details.



Activity	Frequency	Relative frequency
Patient Record	732	30.86%
Bloodletting	430	18.13%
Abdominal Ultrasonography	321	13.53%
MR, BT, USG	280	11.80%
Check-up Report	192	8.09%
Lung X-Ray	128	5.40%
EKG	105	4.43%
Other Examinations	94	3.96%
Mammography	90	3.79%

Fig. 1: Activity frequencies.

Figure 2 shows the discovered process model in Disco. The process map is the most important analysis result in Disco. It shows you how your process has actually been executed. The process flows that you see in the Map view are automatically reconstructed ("discovered") based on the sequence and timing of the activities in your imported event log data. So, without further knowledge about the process, or any pre-existing process model, you obtain an objective picture of the real process.

In the discovered process model, only the most dominant paths in the process map is used to show the paths instead up to all connections between activities that have occurred. This means that only the most dominant connections between these activities are shown. Disco makes sure that all your activities are always connected and avoids getting "dangling" process fragments that cannot be put in context with the remaining activities even if you look at a simplified process map. On the other hand, all activities in the process are shown. 'Bloodletting' has been performed 200 times directly after the activity 'Patient Record' but 176 times the process has returned to 'Patient Record'. This is because we use only the most dominant paths.

Activities are represented by boxes and the process flow between two activities is visualized by an arrow. For example, there are 430 cases in the data set that all start with the activity Bloodletting. Dashed arrows point to activities that occurred at the very beginning or at the very end of the process. The absolute frequencies are displayed in the numbers at the arcs and in the activities. For instance, after the activity 'Patient Record', the process splits into three alternative paths: In 90 cases the activity 'MR, BT, USG' was performed, 'Bloodletting' was performed in 200 cases. In 203 cases, patients directly left the check-up system. The thickness of the arrows and the coloring of the activities visually support these numbers. Because the path where 200 cases have "travelled through" indicates the main flow in this part of the process, it is visualized by a thicker arrow.

In our study, the activity 'Patient Record' means both saving patient details and iformation desk. Therefore, the activity 'Patient Record' is normally the one that is executed most often (in total 732 times). This comes from the dominant loop with activity 'Bloodletting'. Repeatedly, 'Bloodletting' activity is amended and need to be re-analyzed, which is of course very inefficient and from a process improvement perspective we would need to find out what is going on. Perhaps patients don't know how they are performed to examinatation, and we might resolve the problem by updating the check-up guidelines or providing additional training. 192 check-up reports are completed and created a report. Some others in 203 cases, are stopped earlier in the process.

The graph in Figure 3 shows the mean activity duration of the process. There are 2372 events in 630 different cases. The average duration of a check-up is 59.5 hours.

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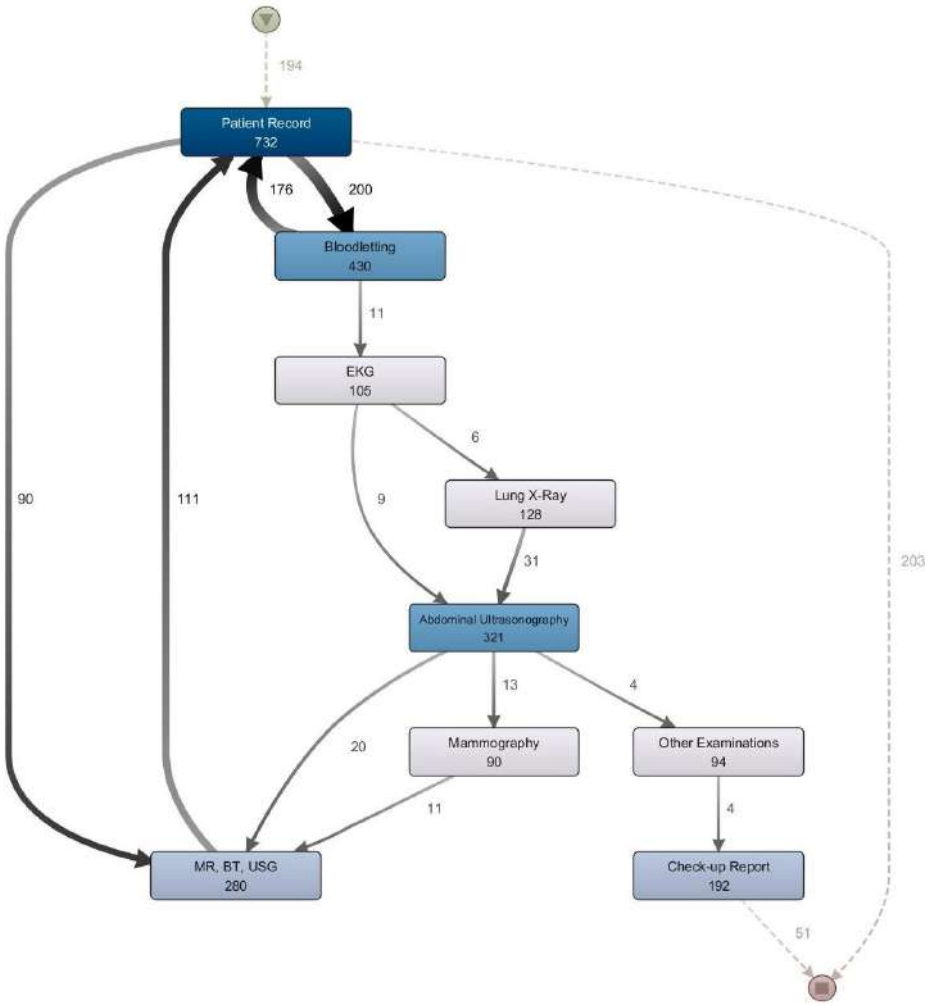

Fig. 2: Discovered process model.

Case ID	Events	Variant	Started	Finished	Duration
34612045	9	Variant 54	15.12.2017 10:01:00	16.12.2017 10:05:00	1 day, 4 mins
38541418	3	Variant 10	15.12.2017 10:07:00	17.12.2017 09:59:00	1 day, 23 hours
39063121	2	Variant 37	15.12.2017 10:09:00	15.12.2017 10:22:00	13 mins
33109839	9	Variant 55	15.12.2017 10:12:00	16.12.2017 12:35:00	1 day, 2 hours
40271267	7	Variant 56	15.12.2017 10:21:00	16.12.2017 17:08:00	1 day, 8 hours
35261493	29	Variant 57	15.12.2017 10:22:00	16.12.2017 10:58:00	1 day, 36 mins
33683153	24	Variant 58	15.12.2017 10:25:00	16.12.2017 10:15:00	23 hours, 50 mins
17103096	6	Variant 59	15.12.2017 10:29:00	28.12.2017 19:14:00	13 days, 8 hours
35303834	4	Variant 60	15.12.2017 10:29:00	16.12.2017 11:31:00	1 day, 1 hour
42615791	3	Variant 48	15.12.2017 10:30:00	15.12.2017 11:54:00	1 hour, 24 mins
18015162	4	Variant 61	15.12.2017 10:32:00	16.12.2017 14:44:00	1 day, 4 hours
38428442	1	Variant 1	15.12.2017 10:32:00	15.12.2017 10:40:00	8 mins
41639760	13	Variant 62	15.12.2017 10:36:00	16.12.2017 10:42:00	1 day, 6 mins
16767780	3	Variant 24	15.12.2017 10:40:00	18.12.2017 10:13:00	2 days, 23 hours
38563778	1	Variant 2	15.12.2017 10:41:00	15.12.2017 11:01:00	20 mins
25899048	4	Variant 63	15.12.2017 10:43:00	18.12.2017 11:38:00	3 days, 55 mins
31236245	10	Variant 64	15.12.2017 10:43:00	23.12.2017 16:26:00	8 days, 5 hours
34163237	10	Variant 65	15.12.2017 10:45:00	16.12.2017 12:42:00	1 day, 1 hour
30743518	5	Variant 66	15.12.2017 10:48:00	18.12.2017 11:06:00	3 days, 18 mins
25754902	9	Variant 67	15.12.2017 10:50:00	19.12.2017 17:40:00	4 days, 6 hours
38653230	3	Variant 68	15.12.2017 10:52:00	27.12.2017 10:20:00	12 days, 8 hours
32918407	3	Variant 20	15.12.2017 10:55:00	18.12.2017 14:59:00	3 days, 4 hours

Fig. 3: Mean activity duration.

CONCLUSION

According to the study, the application of process mining techniques in combination with hospital information systems provides an easy to use way to success a global view of the processes. In this work, we have stated that the process mining can capture the features of the processes, showing them in an easy and understandable view that is accepted by the medical staff in a real environment. With this information, the health professionals and managers can achieve a real view of the problems that are currently happening in the analyzed area. This enables them the improvement of processes with a better

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knowledge of the problems, increasing their efficiency and the probability of success for their further deployment in the real context.

In order to apply the results achieved in this study to any another context, it is necessary to deal with the spaghetti effect limitation. The spaghetti effect is a well-known effect that decrease the understandability of flows in very complex problems. Using different levels of Path slider and Activity slider, the level of detail in the process model can be adjusted.

For further researches, increasing the filters over the event log can provide interesting views about the process in order to achieve specific knowledge of some details of the process. For example, it is possible to infer the process flow of patients with a specific check-up stage. In this way, this paradigm can be very useful to achieve more and better findings for an increase the quality of service in healthcare centers.

CONFLICT OF INTEREST

The author declares no conflict of interest

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None

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