Hospital Performance Improvement Method Using Modified Particle Swarm Optimization

Bagas Satya Dian Nugraha, Rahmadwati, Sholeh Hadi Pramono

Abstract— **Hospitals always need to improve their performance. These performance improvement require an analytics system that integrates clinical data, financial, human resources, and other the organization's data sources. SWOT analysis might be the one of the solution for performance measurement. It also has been frequently used by experts for improving performance. But, SWOT analysis doesn't prioritize issues, doesn't provide solutions or offer alternative decisions, it also generate too many ideas without help to choose which one is best and even more produce lots of useless information. In this research, Modified Particle Swarm Optimization (M-PSO) algorithm used to improve the hospital performance that is to reach a target performance using the optimum development of hospital resources. A target is the value of Key Performance Indicator (KPI) of the SWOT analysis, and based on Critical Success Factor (CSF) to choice strategic implementation. Experimental results show that this method can produce appropriate strategies to improve hospital performance.**

Index Terms— **hospital performance, business intelligence, particle swarm optimization**

I. INTRODUCTION

Healthcare sector is one of the most dynamic sectors of the economy, and health has become one of the major priorities in many countries. Moreover, healthcare is no longer just a service but also a business activator. Hospital own the biggest role in healthcare industry. As a healthcare provider, hospital have performances indicators, such as clinical outcomes, patient satisfaction and organizational costs changes. Clinical outcomes are changes in health status, usually due to an interventions.

Achieving good patient health outcomes is the fundamental purpose of healthcare [1]. Meanwhile, patient satisfaction is a measure of the extent to which a patient is content with the healthcare which they received from healthcare provider. It is an important and commonly used indicator for measuring the quality in healthcare, since patient satisfaction affects clinical outcomes [2]. With these indicators the hospital is able to improve its performance. Hospital performance improvement require an analytics system that integrates clinical data, claims, financial, operational, facilities, equipment, human resources, and the need to consider many factors such as demographic changes, increasing demand for health services, and competition by other healthcare provider [3].

"You cannot manage what you cannot measure" [4] [5]. In the case of healthcare, organization must be able to identify opportunities for reducing costs and improving quality, and monitor whether those opportunities are being successfully addressed. SWOT analysis might be one of the solution for performance measurement. SWOT analysis has been widely used by experts to determine the factors that affect the quality of performance in a company [6]. SWOT analysis is able to detect environmental factors, both external and internal factors so that to define the strengths and weaknesses including opportunities and threats that occur in a healthcare provider [7]. But, SWOT analysis doesn't prioritize issues, doesn't provide solutions or offer alternative decisions, it also generate too many ideas without help to choose which one is best and even more produce lots of useless information [8] [9].

This weakness of SWOT then bring up a system which is called Business Intelligence System (BIS), it is a technology-driven process for analyzing data and presenting actionable information to help corporate executives, business managers and other end users make more informative business decisions. BIS use a wide variety of technology, methodologies and their applications, that enable organizations to collect data from internal systems and external sources, prepare and analyze it, develop and run queries the data using algorithms, create reports, and show result visualizations in the dash board [10]. The visualization of BIS dashboard illustrated in Fig 1.

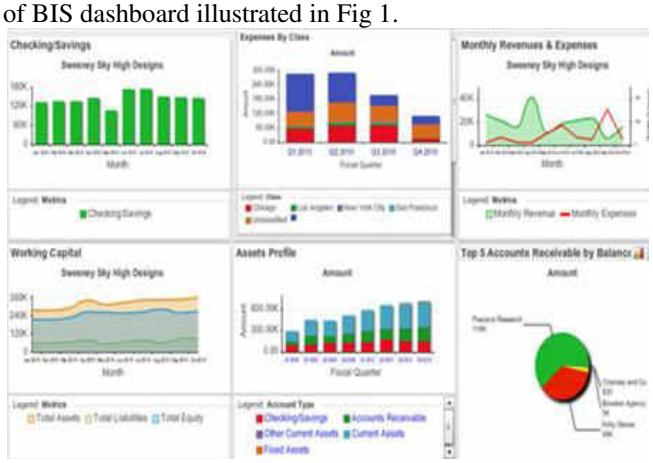

Fig 1. Visualization BIS Dashboard

In the development of BIS, artificial intelligence algorithm can be applied to BIS in order to get optimization with better performance [11]. Particle Swarm Optimization (PSO) is one of artificial intelligence algorithm that can applied in BIS [12]. Particle swarm optimization (PSO) is a stochastic optimization technique motivated by the social behavior of

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fish schooling and bird flocking [13]. PSO shares many similarities with evolutionary computation techniques such as Genetic Algorithms (GA). The system is initialized with a population of random solutions and searches for optima by updating generations. However, unlike GA, PSO has no evolution operators such as crossover and mutation. In PSO, the potential solutions, called particles, fly through the problem space by following the current optimum particles. Compared to GA, the advantages of PSO are that PSO is easy to implement and there are few parameters to adjust [14].

Although PSO has an advantages in its implementation, the problem is still often found in the optimization process. Basic PSO is more appropriate to process static, simple optimization problem. Therefore modification PSO is developed for solving the basic PSO problem [15]. Some modified PSOs are single solution PSO, niching with PSO, constraint optimization using PSO, multi-objective optimization, dynamic environment of PSO, and more. This variations of PSO developed to improve speed of convergence and quality of solution found by the PSO.

In this research, an introducing of BIS was developed. This BIS using PSO to find strategies to reach a target. A target is Key Performance Indicator (KPI) of the SWOT analysis, and based on Critical Success Factor (CSF) to choice strategic action to goal the performance target.

II. PROPOSED SYSTEM MODELLING

The proposed research framework described on Fig 2. This figure describe the step of research work in accordance with the flow of the data. Directions are black, indicating the order of data, whereas red directions indicate data displayed on desktop or dashboard. System modelling is also dividing into two main parts, part A is part composed of computational data processing. While part B, is the part where the development strategy is implemented (implementation phase).

The initial step of the research begins with Critical Success Factor (CSF) search. As the name implies, the purpose of CSF is determination of the set of factors that the manager considers critical for the company success. Once identified, these factors are stated as the objectives and the information required to monitor the company performance is then identified [16] [17] [18]. With this CSF, the company especially hospital can identify the factors that determine the success of health service management at the hospital.

Once CSFs is obtained, the next step will be defining Key Performance Indicator (KPI). A Key Performance Indicator is something that can be counted and compared. It provides evidence of the degree to which an objective is being attained over a specified time. For each CSF there must be one or more associated KPI that provide measure, and a standard of performance or allowable variance from planned performance. Without performance indicator company will not know the extent to which the company's success. Or in other instances, the company can achieve success if the company has met the standardized assessment indicator that refers to key performance indicator itself.

These two objects, CSF and KPI obtained by interview and question and answer with hospital management, implemented by questionnaire. CSF will be addressed to the hospital management department, while KPI is addressed to patients and customers with the aim of knowing patient satisfaction. In the process of determining KPI and CSF using question and answer method, also conducted SWOT analysis. The function of this SWOT analysis is to know the strength and weakness, also opportunities and threats that occur in the hospital environment, so we get specific considerations for each development strategy obtained.

The discovery of CSF, KPI, and SWOT analysis led to the start of Particle Swarm Optimization process. PSO use the KPI assessment result as the initial reference value of hospital performance, which is in this research called Actual KPI. To be able to perform optimization process, PSO require target. This target serves as a goal to be achieved in the PSO process. Without a target, the PSO process will become limitless, and less accurate. The target is determined by how well the performance of the actual KPI increases. PSO process generates a new KPI value. Where the value of the new KPI is a value that will be used as a reference development strategy. But the new KPI value needs to be processed again using a certain algorithm that can translate the value of PSO processing into a language that is easy to read and understood by the end user (General manager or executive). The result of the processing is a development strategy that is ready to be implemented.

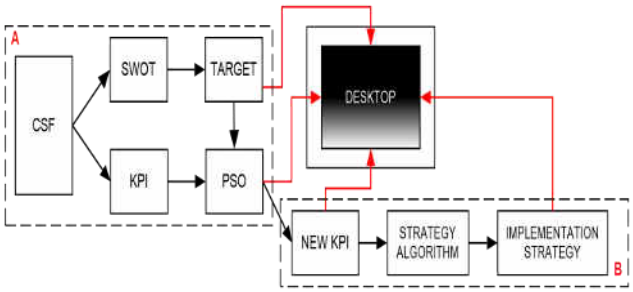

Fig 2. System Modelling

The desktop as a dashboard contains all the information needed to get a development strategy. Target, PSO operations, new KPI values, and implementation strategies are displayed on the dashboard. This way users can monitor the search process of development strategy optimized by PSO and then implement it

III. METHODOLOGY

To be able to realize the improvement of hospital performance, this research is done in three stages of process. First, observing and distributing questionnaire, second searching for correlation between KPI and hospital performance, and third, implementation of PSO for development strategy.

A. Observation and Questionnaire Distribution

Quantitative methods are used in order to collect the research data. This data collections is implemented by giving questionnaires to a number of respondents. Questionnaires contains questions that related to critical success factor of hospital that refer to Likert scale. Likert scale is a psychometric response scale primarily used in questionnaires to obtain participant's preferences or degree of agreement with a statement or set of statements [19].

Most commonly seen as a 5-point ranging from strongly agree, agree, neither, disagree, and strongly disagree. But in accordance to the KPI assessment, the 5-point ranging is slightly modified to be very satisfied, satisfied, neither,

dissatisfied, highly dissatisfied with each level on the scale is assigned a numeric value as follows in the table 1.

Table 1. Likert Scale

Answers	*Score*
Very Satisfied	5
Satisfied	4
Neither	3
Dissatisfied	2
Highly dissatisfied	1

The questionnaire was given to 100 respondents. Assessment of each questionnaire will be tabulated and then analyze correlation with KPI and SWOT. The results of the correlation analysis can be taken into consideration in the PSO process to get the final result of the development strategy. The flow diagram to obtain the questionnaire data is shown in Fig 3.

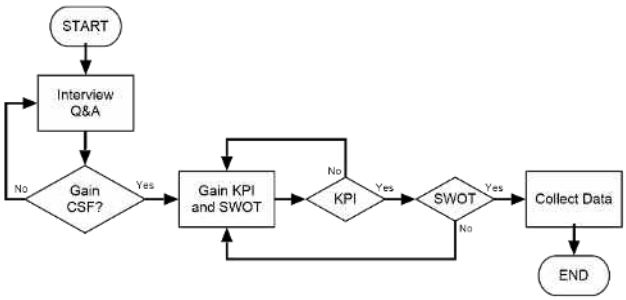

Fig 3. Questionnaire Flowchart

B. Correlations between KPI and Hospital Performance

The correlation modeling between KPI and hospital performance is determined from the number of assessment units of the questionnaire, which is related to the performance of the hospital. Each KPI appraisal unit is annotated by x, whereas for hospital performance is annotated by y. Illustration of the correlation between KPI and hospital performance is shown in Fig 4.

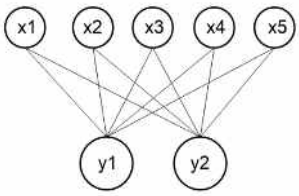

Fig 4. Correlations Design KPI-Hospital Performance

This correlation aims to find out how the influenced of each unit assessment on the performance of the hospital. By knowing the correlations will be easier to get right on targeted development solution.

C. Implementation of PSO

1) General PSO Algorithm

Particle Swarm Optimization (PSO) algorithm is a popular and useful tool for solving any kind of engineering optimizations over the few years which firstly proposed by Kennedy and Eberhart 1995. PSO is a stochastic optimization technique motivated by the social behavior of fish schooling and bird flocking. The PSO mechanism uses a velocity vector to update the current position of each particle in the swarm. While flying, each particle adjusts its position based on its own experience and that of the most successful particle. The velocity v_i and the position x_i of each particle i are updated, respectively, follows (1) (2):

$$v_i(t+1) = v_i(t) + c_1.\eta_1.\left(pbest_i(t) - x_i(t)\right) + c_2.\eta_2.(gbest(t) - x_i(t)) \quad (1)$$

$$x_i(t+1) = x_i(t) + v_i(t+1) \quad (2)$$

Where, $v_i(t)$ and $x_i(t)$ are, respectively, the velocity component and the location component of particle i at iteration t; $v_i\ (t+1)$ and $x_i(t+1)$ are, respectively, the velocity component and the location component of particle i at iteration $t+1$; $pbest_i$ is the best location of particle i, and $gbest_i$ is the global best location of the whole swarm; c_1 and c_2 are respectively, the cognitive and social parameters, and η_1 and η_2 are uniform random numbers in the range [0, 1]. Fig 5 presents a flowchart summarizing the logical of the PSO.

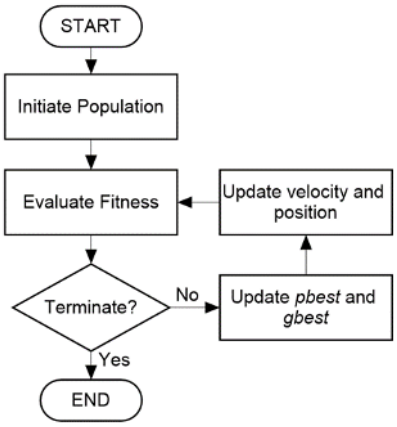

Fig 5. PSO Algorithm Flowchart

2) Modified PSO Algorithm

It is worthy of notice that only one global best particle of the population, gbest, is enrolled in the general PSO algorithm. In this manner, only one corresponding system solution can be caught by the gbest for the optimized problem. For solving the multimodal function optimization, it is rather improper and not applicable because the multimodal function consists of several system optima including global optimal solution and local optimal solutions.

To tackle this problem, a modified version of PSO algorithm is developed, which the concept of subpopulations is utilized for solving multimodal functions [20]. The following modified PSO algorithm is shown in Fig 6.

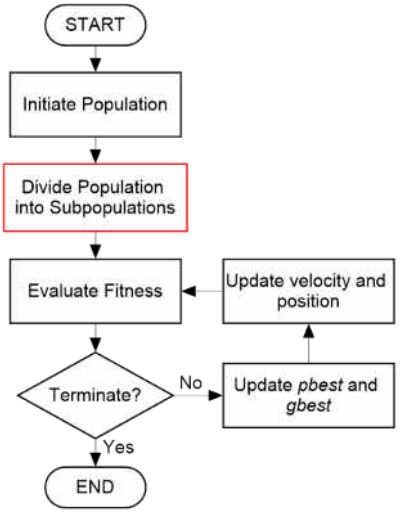

Fig 6. Modified PSO Flowchart

The original single population that has been initialized divided into several subpopulations according to the needs and also to the order of the populations. Using this method each subpopulation are separately able to catch different optima, not as the global best particle in the whole population. In this study PSO simulation is built using Matlab computing software application and under the environment of Intel(R) Core(TM) i5-4200H CPU @2.80GHz.

3) Development Strategy Algorithm

Development strategy is the output of the system built. But the result of PSO processing need to be initialized into a development strategy solution in user-readable language. The goal is that the solution can be implemented immediately. Besides, the development strategy solution also need to be matched with KPI and SWOT. The flowchart of the development strategy algorithm is show in Fig 7.

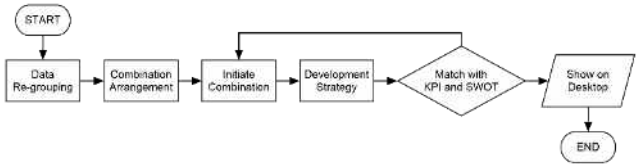

Fig 7. Development Strategy Flowchart

Data re-grouping, combination arrangement, and combination initialization aim to find pairs of KPIs and performance that require development. Thereby providing a solution for each pair of KPIs and performance by considering the value of previous KPI and SWOT as well. After that, a suitable solution will be displayed into the desktop which is then read by the end-user.

IV. RESULT AND DISCUSSION

A. Observation and Questionnaire Distribution Result

Observation was conducted at a health service under the name Poliklinik Universitas Brawijaya, Malang, Indonesia. To get 100 respondents, observation is done in 7 days, considering that the average of visitors every month reaches 700 hundred people. So if taken into account, the average visitor each day is about 35 people. This number has included visitors that came for health control who could have come in a few days in a row.

Questionnaires that have been responded, collected, tabulated, and taken an average of 100 respondents. After the average value is obtained, the calculated result is rounded and then converted to a matrix. This matrix works to facilitate programming under the Matlab software environment. The resulting matrix has a [1x35] order that is valued as follows.

Data = [4 4 4 4 4 4 3 4 4 4 4 4 4 4 4 4 4 4
4 4 4 4 4 4 4 4 4 4 4 3 3 3 3 3 3]

B. Correlations of KPI and Hospital Performance

Based on the design obtained, correlation between KPI and hospital performance is illustrated in Fig 8. Assessment unit obtained 35 units, while for performance obtained 3 categories. The thirty-five units are divided into 6 categories, namely reliability, assurance, tangible, empathy, responsiveness, and supporting data each symbolized by x. Whereas for performance divided in human resources performance (K1), service quality performance (K2), and completeness of facilities (K3). Not all assessment unit are correlated with the same performance. In the illustration, each unit has one correlation to each performance. In principle, this correlation analysis aims to determine which units will affect the performance so that improvement can deliver right on target result.

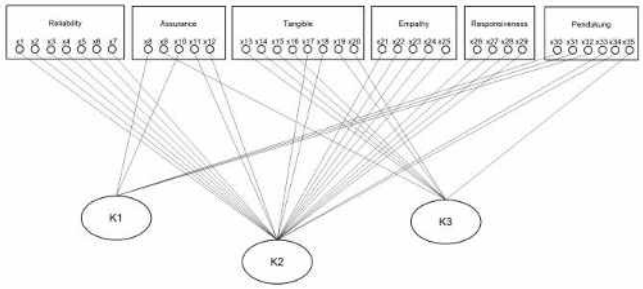

Fig 8. Correlation Analysis KPI - Hospital Performance

C. PSO Performance

In order to facilitate the understanding and discussion of PSO performance, some figures are used to explain it. Each figure show two displays, first, is the plotting display of the KPI value on each unit, second, is the plotting display of maximum iteration gained by PSO optimization to get convergence. As already known, the actual KPI value gained from observation and questionnaire described in *Observation and Questionnaire Distribution Result* sub-section. That value in average then calculated the percentage based on the maximum value of KPI, is worth 80%. This value is then called Performance of KPI that obtained by the following formula (3)

$$\left(\frac{Rounded\left(\frac{sum\ n}{\sum n}\right)}{\max m}\right) x100\% \qquad (3)$$

$$= \frac{4}{5} x100\%$$

$$= 80\%$$

Where, $sum\ n$ is respectively the total of the average KPI value, $\sum n$ is respectively an amount number of KPI value, and $max\ m$ is respectively the maximum value of KPI.

The 80% value is the minimum value for the PSO performance to make improvements to the actual KPI value. So improvements can only be made above those percentages. For example, a PSO optimization performance with a minimum target of 80%, with 250 maximum iterations, and velocity 0.05 are shown in the Fig 9.

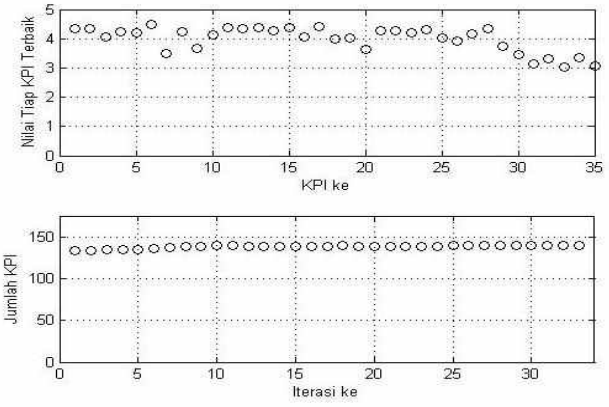

Fig 9. PSO Performance on 80% Target

The PSO process does not require much time and iteration to reach convergent. This is because the increase of KPI value

only given at the minimum target only, that is not more than 80%. The figure shows that the maximum iteration is reached at a number around 30 close to 40. Whereas the value of KPI has an increase about 3 and 4, none of which reach value of 5. Different cases when the target is raised to 90% or 100%. The PSO performance of both targets is shown in Fig 10 and 11.

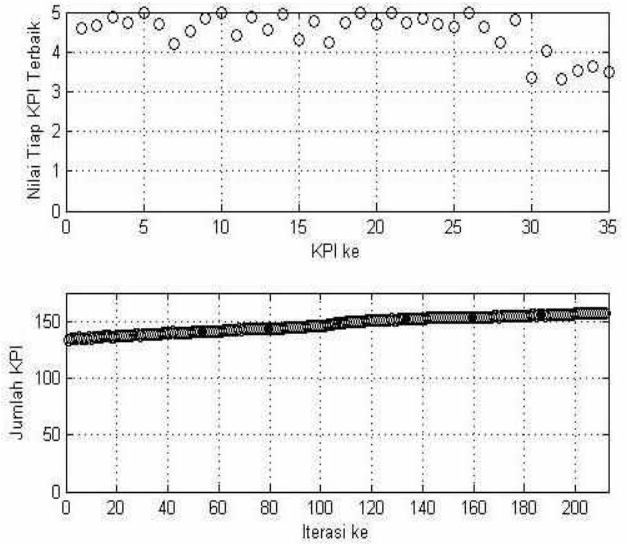

Fig 10. PSO Performance on 90% Target

Can be seen in the figure that the optimization of PSO takes a little longer than before, and with the iteration reaching to the maximum 250. This indicates that the PSO is working harder to be able to raise the value of KPI which previously averaged 4 to at least reaching an average of 5. The same thing happened on PSO optimization with 100% target. If the target given is at 80% and 90%, PSO can achieve at least average 5 of KPI value, 100% target on PSO should be able to optimize the value of KPI to maximum value on all units in 5. It means, on the Fig 11, all the KPI values should be at the top of the diagram.

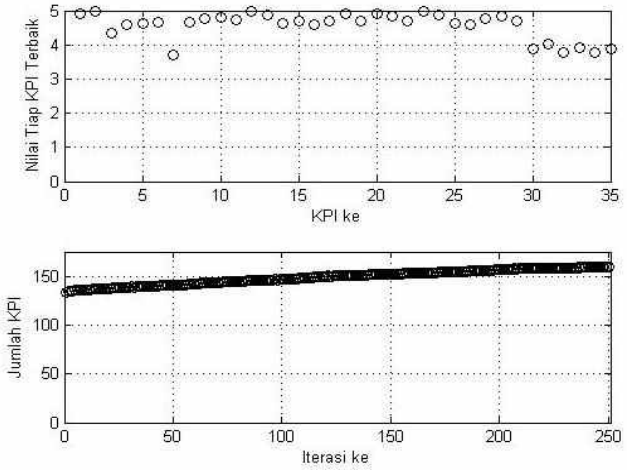

Fig 11. PSO Performance on 100% target.

But it seems like not all of the KPI value are at the top of the diagram. Things that affects are the maximum range of iteration initialized as a parameter of PSO optimization. For example, the maximum iteration is raised to 1000, 4 times larger. PSO will give KPI optimization value which corresponds 100% actual increase. However, a consequences must be taken, the optimization takes much longer to convergence. Performance optimization of PSO with 1000 maximum iteration shown in the Fig 12

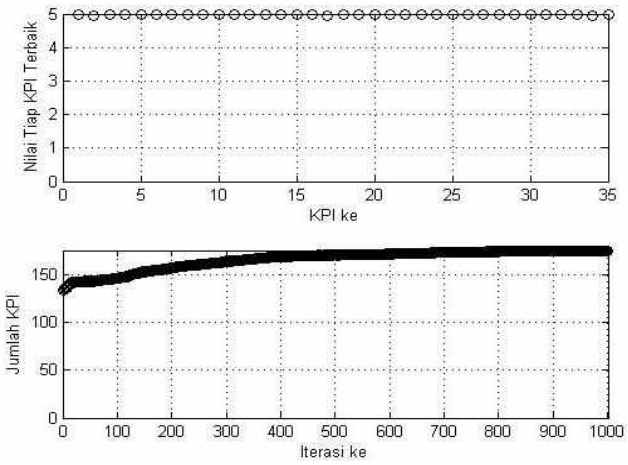

Fig 12. PSO Performance on 1000 Max Iteration

D. Development Strategy

Development strategy is measured by the increase in value between the average of actual KPI and the average value of the new KPI produced by PSO. There are three development strategies generated by the correlation between the value of KPI and hospital performance, as described in Correlations of KPI and Hospital Performance sub-section, i.e. human resource performance, service performance, and facilities. This is where the role of modified PSO works. The population of 35 KPI units is divided into several subpopulations in accordance with the impact to the hospital performance. Unit 1 to 15 are classified into human resource populations. Unit 16 to 25 are classified into service performance populations. Then unit 26 to 35 are classified into the completeness facility populations. Development strategy considered SWOT analysis in providing solutions to hospital. The purpose of this consideration is that the given solution does not deviate from the core of the solutions obtained from the SWOT analysis. To simplify, the development strategy is stated as follows.

If $x = a$, $x' = b$ Then, result "Strategy 1"

Where, x is refers to the actual KPI, x' is refers to the new KPI, a and b is for corresponding value. When translated in logical language, the statement means.

> If the value of Actual KPI is a, then after optimization, the Actual KPI value becomes New KPI with value b, then it shown "Strategy 1" as the development solution.

"Strategy 1" is just an example used to present the results of the statement. When applied to the simulation it will produce the following graphic and development strategy as shown in Fig 13.

The graphic shows the difference in KPI value from the three performance classifications, also compare between Actual KPI and New KPI. Graph 1-2 shows the change of KPI value on human resource performance, 3-4 graph shows the change of KPI value on service performance, and graph 5-6 shows the change in facility improvement. The value of KPI that experienced an increase occurred in the performance of service and facilities, while the performance of human resources did not increase so as to produce a statement "no available development strategy". Whereas at the value of service and facility, KPI increase from 4 to 5 and from 3 to 4, resulting a statement as shown in Fig 13

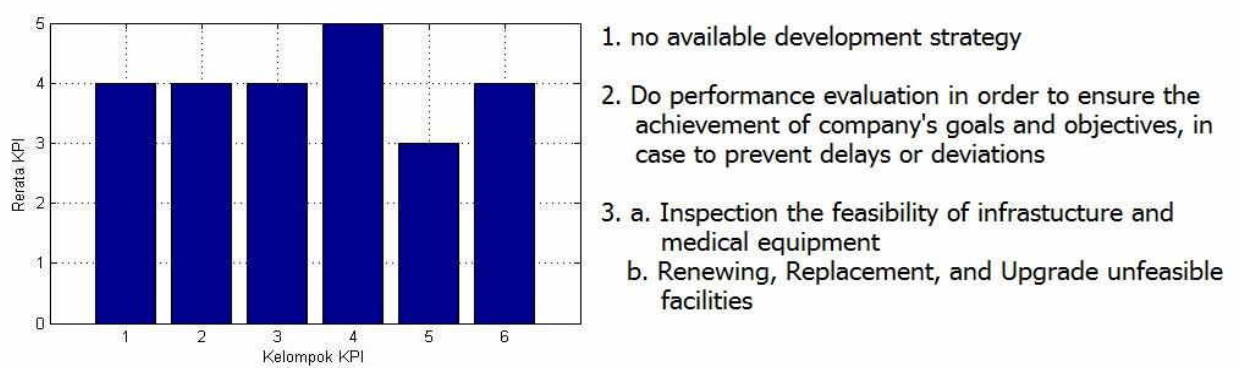

Fig 13. Performance of KPI and Development Strategy on Dashboard Display

CONCLUSION

In conclusion, the improvement of hospital performance that was previously done manually and requires a lot of personal, can be handled with the implementation of business intelligence using PSO optimization. Performed by only one or a few end users (general manager or executive), this system can provide a fairly effective and time-saving development strategy. Hospitals or other healthcare providers need only to maximize the resources they have to grow and improve performance with an indicator of patient satisfaction.

For future research, it is recommended to make additional respondents in getting patient satisfaction, and need to be done at hospitals with greater capacity. Also, in addition, the assessment of hospital performance needs to be more thorough and detailed, if necessary, the assessment can be conducted based on quality assessment standard or hospital accreditation.

REFERENCES

[1] B. Roy, "Healthcare Outcomes". [Online]. Abailable: http://www.shouldersurgery.info/overview-of-healthcare-outcome/

[2] B. Prakash, "Patient Satisfaction," *Journal of Cutaneous and Aesthetic Surgery,* vol. 3, no. 3, 2010.

[3] S. Felder, "Managing The Healthcare System - The Impact of Demographic Change on Healthcare Expenditure," *CESifo DICE Report,* vol. 11, no. 1, pp. 3-6, 2013.

[4] H. Lingard, R. Wakefield and N. Blismas, "If You Cannot Measure It, You Cannot Improve It : Measuring Health and Safety Performance in The Construction Industry," *19th Triennial CIB World Building Congress.*

[5] K. R. Paisley and W. T. Henshaw, "If You Can't Masure It, You Can't Manage It : Transboundary Waters, Good Governance and Data & Information Sharing & Exchange," *Indiana International Comparative Law Review,* vol. 24, no. 1, 2014.

[6] H. -H. Chang and W. -. C. Huang, "Application of a Quantification SWOT Analytical Method. Mathematical and Computer Modelling," *Elsevier,* 2005.

[7] M. M. Helms and J. Nixon, "Exploring SWOT Analysis - Where Are We Now?," *Journal of Strategy and Management,* vol. 3, no. 3, 2010.

[8] F. Popescu and C. Scarlat, "Limits of SWOT Analysis and Their Impact on Decision in Early Warning Systems," *SEA - Practical Application of Science,* vol. 3, no. 1, 2005.

[9] "Limitations of SWOT Matrix," [Online]. Available: https://www.edrawsoft.com/swot-limitations.php.

[10] Rouse. M., "Business Intelligence (BI)," October 2014. [Online]. Available: http://searchdatamanagement.techtarget.com/definition/business-intelligence.

[11] J. Chaturvedi, A. Parashar, A. A. Manjrekar and V. S. Bhaskar, "Social and Business Intelligence Analysis Using PSO".

[12] G. M. Epitropakis, "Business Intelligence : Optimization for Decision Making," *Computational Heuristics, Operational Research and Decision Support CHORDS,* 2015.

[13] R. C. Eberhart and J. Kennedy, "A New Optimizer Using Particles Swarm Theory," *Proceedings of the 1997 IEEE International Conference on Systems, Man, and Cybernetics,* pp. 4104-4108, 1995.

[14] X. Hu, "PSO Tutorial," 2006. [Online]. Available: http://www.swarmintelligence.org/tutorials.php.

[15] D. P. Rini, S. M. Shamsuddin and S. S. Yuhaniz, "Particle Swarm Optimization : Technique, System, and Challenges," *International Journal of Computer Applications,* vol. 14, no. 1, pp. 19-27, January 2011.

[16] O. Alaskari, A. M. M., Dhafr and P. C. R., "Critical Success Factors (CSFs) for Successful Implementation of Lean Tools and ERP Systems," *Proceedings of the World Congress on Engineering 2012,* vol. 3, 2012.

[17] E. JM., "Definition and Analysis of Critical Success Factors for ERP Implementation Projects," 2005.

[18] A. Omran, M. A. Abdulbageh and A. O. Gebril, "An Evaluation of The Critical Success Factors for Construction Projects in Libya.," *Journal of Economic Behavior,* vol. 2, 2012.

[19] D. Bertram, "Likert Scales," *CPSC 681 - Topic Report,* vol. 1, no. 11, 2006.

[20] W. D. Chang, "A Modified PSO with Multiple Subpopulations for Multimodal Function Optimization Problems," *Applied Soft Computing - Elsevier,* 2015.

[21] P. C. Smith, "WHO European Ministerial Conference on Health Systems : Health Systems, Health, and Wealth," 2008.

[22] T. A. Sheldon, "The Healthcare Quality Measurement Industry : Time to Slow Juggernaut?," *BMJ Journals,* vol. 14, no. 1, pp. 3-4, 2015.

[23] B. Roy, "Cyber Security for Virtual Clinics," *The Institution of Engineering and Technology,* 2016.

[24] S. Nithyananth, A. Suganya and M. Menakapriya, "Data Warehousing and Data Mining in Business Applications," *International Journal of Engineering Research and Management (IJERM),* vol. 2, no. 1, pp. 7-11.

[25] C. C. Lo and T. H. Lin, "A Particle Swarm Optimization Approach for Physician Scheduling in a Hospital Emergency Department".

[26] H. A. Halim, N. W. Setyanto and R. Y. Efranto, "Determination of Management Strategy Based on Performance Prism and SWOT Analysis," *Jurnal Rekayasa dan Manajemen Sistem Industri,* vol. 3, no. 1, 2015.

[27] V. E. Gueorguiev, D. V. Georgieva and I. E. Ivanov, "New Healthcare Challenges Require New Generation of Hospital Information Systems," *International Journal of Engineering Research and Management (IJERM),* vol. 3, no. 8, pp. 7-13, 2016.

[28] A. R. A. Dahlan, E. Emir, M. Helmi, A. Sobri and M. Azli, "Optimising Information System in Business," *International Journal of Engineering Research and Management (IJERM),* vol. 3, no. 12, pp. 35-39, 2016.

[29] R. Armand, G. Jafarzadeh and M. Rastegari, "Effect of Enterpreneurship Communication Skills of Sport Business Managers on Customer Satisfaction," *International Journal of Engineering Research and Management (IJERM),* vol. 3, no. 12, pp. 52-54, 2015.

[30] M. Afzal, F. Rizvi, A. H. Azad, A. M. Rajput, A. Khan and N. Tariq, "Effect of Demographic Characteristic on Patient's Satisfaction with Healthcare Facility," Journal of Postgraduate Medical Institute, vol. 28, no. 2, pp. 154-160, 2014.

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