Examination of Self-Medication Using Taguchi Method - A Case of Rural India

Dr. Rajesh Singh,

Assistant Professor Institute of Engineering and Technology, Deen Dayal Upadhyay Gorakhpur University, Gorakhpur, UP Email- rajeshsinghiitbhu@gmail.com

Dr. Vinaytosh Mishra

Associate Professor FORE School of Management, New Delhi, India Email: vinaytosh@fsm.ac.in

Ekta Tiwari MBA Madan Mohan Malaviya University of Technology, Gorakhpur Email- ektatiwari2774@gmail.com

Mohammad Faisal Masood Khan MBA

Madan Mohan Malaviya University of Technology, Gorakhpur Email- mfmk269@gmail.com

Abstract

Self-Medication and increased reliant on home remedies is one of the prevalent healthcare problems in rural India. The main reason behind self-medication is the unavailability of a registered medical practitioner and the financial hardship of the rural people. Moreover, the healthcare infrastructure is not up to mark in the rural part of India. This study surveys the hazard associated with self-medication practice and breaks down the effect of locally widespread self-medication phenomena in rural India. The use of intuitive homemade remedies for the treatment of fever is very common in the Jharkhand state of India. Excessive use of such practices may sometimes prove to be dangerous and even fatal. This study uses the Taguchi Method to reduce analyse the problem associates with self-medication practices and hence improve the quality of life. Taguchi Method is a statistical method for improving the quality of manufactured goods and more recently also applied to other fields like healthcare, marketing, and advertising. The study concludes that reluctance to spare money and time in hospitals is the primary reason behind the people resorting to self-medication practices. The study also concludes that there is a lack of awareness among rural residents about the risk associated with these practices. The study identifies the noise factors and control factors to be looked after to increase the quality of life. Finally, the study concluded that controlling the delays in seeking medical advice from the registered practitioner and non-reliance on selfmedication can improve the health outcomes in rural India. The study is the first of its kind applying the Taguchi Method to provide an approach for managing self-medication and hence improving the quality of life. The study contributes to the theory of preventive and social medicine (PSM) and public health.

Keywords: Self-Medication, Health Risk, Quality of Life, Taguchi Loss Function, Preventive and Social Medicine.

Introduction

Self-medication is one of the major healthcare problems in developing

countries. It delays medical interventions and becomes fatal in many cases. Self-medication can be described as the choice of medicines and their individual use for the treatment of self-diagnosed and self-perceived side effects and infections without any specific prescription. In India, 8.6% of the total population belongs to the tribal community, and 68.84% live in rural parts of India. After more than seventy years of independence, rural India is still deprived of essential and primary care. Due to a lack of awareness, these rural and tribal residents of India treat themselves with their home remedies, which they have learned from their ancestors. They cure themselves by making the medicines from herbs and plants available in nature and attempt to treat the severe disease and infections (Azam et al., 2012). There are many cases of public as well as professional issues related to self-medication that have been reported and it is imperative to discourage such practices (Abosede, 1984; Ong et al., 2016).

Self-medication is the activity of handling any selfdiagnosed disease or illness by using non-prescribed medicines or home remedies without taking the advice of a doctor or taking any help from medical facilities. Factors such as easy availability of the medicines, increase of cost of healthcare, and inertia against visiting doctors are the reason behind self-medication. Which may lead to overconsumption of dosage, adverse reaction, incorrect diagnosis, and treatment (Alhomoud et al., 2017). A study done in china concluded that self-medication at home without any correct guidance can be life-threatening (Wang et al., 2018). The frequency of home-based self-medication varies from population to population. It can be influenced by various factors such as age group, gender, total earning of the family, total expense, awareness level, and medicinal knowledge of individuals (Tshibangu, 2018). The researchers have warned against the misuse of the drugs in young populations (Elizabeth S and Judith A., 2001).

Alhomoud et al. (2017) in their seminal work, reported various reasons behind the abuse of antibiotics and other drugs. This research further suggested that community awareness and implementation of vigorous regulatory enforcement is required for stopping such activities. The studies also reported the high prevalence of such practices in lower-income group as they are not able to see the negative result of using medication without having proper knowledge about their side effects and interaction with other medicines (Albatti et al., 2017).

Anti-microbial self-treatment is commonly practiced in low and medium earning countries. The negative outcome of these excessive use of anti-bacterial disease ends up in allergies, failure of being cured, and death. Using antibiotics through home-based treatment causes severe illness, and it varies in different communities (Ocan et al., 2015; Wang et al,2018). In a recent study Ghaderi et al. (2020), concluded self-medication not only increases the healthcare risk but also is substantial financial burden on government pharmaceutical resources, various insurance companies and population in general. Thus, creating awareness about self- medication is pertinent to reduce the economic burden resulting from self-medication. (Karimy et al., 2019). The indirect cost associated with visiting the hospital is significantly high which is one of the reasons behind people resorting to self-medication (Isabel Tavares, 2013; Mustafa & Rohra, 2017). Another study concludes that switching from one healthcare provider to other by a patient can be detrimental for their health. Moreover, it also results in extra cost which can profoundly affect their treatment and ultimately their health (Limaye et al., 2018). It can also lead to psychological damage to the patient's mind as he or she is unable to adjust and comply with different service styles (Abosede, 1984).

Taguchi Method is a statistical tool useful for improving the quality and process permanence (Lofthouse, 1999). Taguchi Method has been used in healthcare for managing the healthcare quality problem (Cho and Cho,2008; Azam et al., 2012; Pandey et al., 2012). It has increasingly used in the Magnetic Resonance Imaging (MRI), radiology, and nuclear medicine (Taner & Antony, 2006).

This study tries to devise a quantitative approach for analyzing home-based medication to limit the subjectivity and hence reduce the risk associate with the selfmedication. The study further illustrates the approach using a case of rural India. Home-based self-medication can be assessed on effectiveness, safety, awareness and old traditional values and beliefs. These previously mentioned components have been included into Taguchi's misfortune work. This study uses an orthogonal array system for the examination of the loss function and specified the area of improvement. Taguchi misfortune work helps in utilizing the misfortune capacity to quantify the exhibition that has been veered off from the real longing worth; these qualities are then changed to signal towards noise proportion. Bases on the reviewed literature, the Figure -1 depicts the conceptual framework for the home based self-medication.

Figure 1: Conceptual Framework for Home Bases Self-Medication



Research Objectives

The objective of this study is to assess the risk involved with home-based self- medication practices in rural India. The study further intends to outline the control and noise parameters in the context of achieving quality in the healthcare.

Research Methodology

This study uses the review of extant literature to identify the identify the apparent gaps by critically analyzing the impact of home-based self-medication, health outcomes and quality of life of patients. A survey on home-based self-medication for the treatment of fever was performed, and data were collected at regular intervals from March of 2019 to June of 2019. For this, eighteen select districts from the

Indian state of Jharkhand were chosen to find the prevalence and adoption rate of home-based selfmedication practices for the treatment of fever. The selected districts include, Pakur, Purbi Singhbum, Latehar, Chatra, Palamu, Godda, Dumka, Jamtara, Gumla, Lohardaga, Khunti, Garhwa, Paschimi Singhbum, Deoghar, Sahibganj, Kodarma, Simdega, and Saraikela Kharsawan. A defined random inspecting procedure was attempted to gather the necessary information. The respondents were taken from governments run Primary Health Centers (PHCs), Community Health Centre (CHCs), and randomly selected private practitioners. The authors of this paper also conducted a structured interview of the patients from rural Jharkhand, to find out the home-based self-medication practices prevalent in the curing of the disease. The interview consisted of questions related to home-based medication and time taken to recover from the illness. The follow-up questions include whether they prefer going to doctors if they don't see improvement due to selfmedication. A systematic model of the Taguchi Loss Function is incorporated in this study to examine its effect on patients' quality of life and home-based self-medication activities. The summary of the survey on home-based self-medication for treatment of fever in depicted in the Table -1.

| S.N. | District | 20 | 19- Ma | arch | 20 | 019- A | oril | 2 | 019- N | lav | 2019- June | | |
|------|------------------------|-----|--------|------|-----|--------|------|-----|--------|-----|------------|-----|-----|
| | | IP | RP | NRP | IP | RP | NRP | IP | RP | NRP | IP | RP | NRP |
| 1 | Pakur | 513 | 94 | 419 | 515 | 103 | 412 | 487 | 89 | 398 | 527 | 106 | 421 |
| 2 | Purbi Singhbhum | 508 | 87 | 421 | 526 | 105 | 421 | 510 | 93 | 417 | 498 | 91 | 407 |
| 3 | Latehar | 494 | 97 | 397 | 520 | 107 | 413 | 512 | 104 | 408 | 517 | 98 | 419 |
| 4 | Chatra | 516 | 96 | 420 | 518 | 95 | 423 | 511 | 102 | 409 | 495 | 103 | 392 |
| 5 | Palamu | 497 | 100 | 397 | 522 | 99 | 423 | 509 | 104 | 405 | 514 | 95 | 419 |
| 6 | Godda | 534 | 148 | 386 | 518 | 157 | 361 | 538 | 162 | 376 | 542 | 146 | 396 |
| 7 | Dumka | 498 | 153 | 345 | 505 | 146 | 359 | 499 | 149 | 350 | 517 | 152 | 365 |
| 8 | Jamtara | 527 | 158 | 369 | 541 | 166 | 375 | 519 | 146 | 373 | 523 | 138 | 385 |
| 9 | Gumla | 510 | 157 | 353 | 497 | 142 | 355 | 531 | 149 | 382 | 529 | 146 | 383 |
| 10 | Lohardaga | 506 | 143 | 363 | 523 | 129 | 394 | 530 | 131 | 399 | 537 | 134 | 403 |
| 11 | Khunti | 497 | 145 | 352 | 504 | 153 | 351 | 511 | 162 | 349 | 539 | 143 | 396 |
| 12 | Garhwa | 502 | 154 | 348 | 509 | 157 | 352 | 524 | 139 | 385 | 541 | 147 | 394 |
| 13 | Paschimi Singhbhum | 518 | 151 | 367 | 525 | 163 | 362 | 498 | 169 | 329 | 536 | 147 | 389 |
| 14 | Deoghar | 522 | 131 | 391 | 534 | 143 | 391 | 510 | 169 | 341 | 541 | 154 | 387 |
| 15 | Sahibganj | 492 | 144 | 348 | 514 | 148 | 366 | 536 | 154 | 382 | 528 | 158 | 370 |
| 16 | Kodarma | 517 | 163 | 354 | 496 | 143 | 353 | 539 | 152 | 387 | 544 | 149 | 395 |
| 17 | Simdega | 521 | 159 | 362 | 529 | 147 | 382 | 489 | 158 | 331 | 499 | 137 | 362 |
| 18 | Saraikela Kharsawan | 504 | 132 | 372 | 516 | 147 | 369 | 537 | 143 | 394 | 489 | 153 | 336 |

Table 1: Survey of Home-Based Self-Medication in Rural Jharkhand

Abbreviations Used: IP= Infected Patients, RP=Recovered Patients, NRP= Non-recovered Patients.

Taguchi Loss Function

The loss function of Taguchi, initially developed by a Japanese businessman Genichi Taguchi is a graphical depiction demonstrating how the deviation from the target leads to the decrease in quality of product and increase in customer dissatisfaction. Taguchi argued that quality of the product must be "engineered in" as it cannot be "inspected out". It is based on the philosophy that "target" is the best value and one who deviates from the target should look at the "loss function". The Figure -2 below depicts the quadratic loss function proposed in Taguchi Method, where LSL and USL being Lower and Upper Specification Limits.

Figure 2: Quadratic Loss Function used in Taguchi Method



Taguchi used a mathematical concept known as Orthogonal Array and a Robustness Concept known as Signal to Noise Proportion, i.e., S/N ratio. The best result is obtained when this (S/N) ratio is maximum, as noise makes the product less robust and more sensitive. If Loss Function is minimized it means less amount of loss to the society. The equation -1 represents the Quadratic Loss Function.

 $L(x) = k(x-t)^2$

- L = cost incurred as quality deviates from the target.
- x = Performance characteristic
- t = Target
- k = Quality loss coefficient.

Steps for the Taguchi Method

The study follows seven step processes to analyze the effect of Taguchi Loss Function on home-based self-medication through the Taguchi Loss Function:

... (1)

- 1. The identification of primary functions: The primary function represents the critical part of the experimentation, i.e., the base upon which the total experiment is conducted. In this research, the, primary function is "Adoption of home-based self-medication in rural parts of India" while side –effects being "Degradation in quality of life".
- 2. Identification of the noise and control factors: Once

the primary function is identified the next step is to find out control and noise factors. For minimizing the noise factors, control factors are improved to maintain the ideal performance of the system. The various control and noise factors associated with home-based selfmedication are mentioned in the experimentation.

- 3. Objective function identification: Taguchi's statistical tool deals with three quality loss capacities or functions. These are 'nominal-the-best', 'littler-the-better' and 'greater-the-better'. This research uses littler-the-better as an objective function. In correspondence to home-based self-medication, the more one deviates from the standard limit of treatment, the riskier it becomes.
- 4. Determination of the control factor levels: In this step the decision upon the choice of elements and their necessary levels for experimentation was decided. The level was decided on basis of discussion of a Focus Group containing five researchers from the field of industrial engineering.
- 5. Selection of orthogonal array: Orthogonal Arrays (OAs) experiment technique is applied in Taguchi's loss function method to consistently determine and examine the different control factors and their associated levels. The degree of freedom used in this study is nine one for the mean while two each for four variables.
- 6. Conducting the experimentation of data: The signal-to-noise proportion (S/N) is how the loss function of Taguchi is introduced into the experimentation. The signal-to-noise proportion estimates the variation of the response about the optimum or standard value in various conditions of noise. Since the objective function employed in this research is smaller-the-better, therefore, the S/N ratio is computed as:

$$N = -\log_{10}\left(\frac{\sum_{i=1}^{n}(x_i - t)^2}{n}\right)$$

where

x_i=Measured value t = Target Value 7. Analysis of the data: In the last step a full factorial analysis of the data is conducted to check the correctness of the experiment. In factorial analysis for the study, all the possible matches of the control factors and their levels are taken into consideration. The

aftereffects of the full factorial examination are then contrasted with the consequence of the partial factorial, i.e., the S/N ratio. The factor with the highest amount of S/N ratio should be selected as it shows the optimum result and better performance.



Figure 3: Application of Taguchi Method in Home Based Self-Medication

Results and Analysis

Based on the reviewed literature and focus group discussion the control factors were identified for the study were (1) Self-diagnosis (2) Delays in looking for medical guidance (3) Reactions and side-effects (4) Dangerous drug interaction (5) Inappropriate dosage (6) Incorrect choice of therapy (7) Unawareness about health consequences (8) Belief about self-medication being beneficial (9) Highquality equipment (10)Maintenance of medical equipment (11)Waiting time in clinics , and (12) Low-cost health services. The noise factors identified for the study were (1) Notion of home-based self- medication being cost-effective (2) Traditional values and beliefs (3) Unemployment (4) Readily available medicines (5) Notion of home-based selfmedication causing no side effect (6) Deterioration of materials (7) Ageing or faltering machinery, and (8) Consumer's usage conditions.

The objective function for the study is smaller –the-better, while it uses three control factors with three levels. These factors were selected after the various consideration and Focus Group Discussion (FGD). The method used for FGD is Delphi Method. The various factors and their levels is listed in Table -2.

| Factors | Levels | | | |
|--|--------|----|-----|--|
| | Ι | II | III | |
| Dangerous drug interaction (monthly) | 5 | 6 | 7 | |
| Adverse reactions and side-effects (in %) | 7 | 8 | 9 | |
| Delays in seeking medical advice (in days) | 6 | 7 | 9 | |

Table-2: Control Factors and Levels

This study has taken orthogonal array (OA) L9 for studying the impact of loss function of Taguchi in home-based selfmedication in rural India. The details of the OA are listed in the Table -3.

| Experiment | | | | | | |
|------------|------------------------|---|---|--|--|--|
| No. | Control factors | | | | | |
| | 1 | 2 | 3 | | | |
| 1 | 1 | 1 | 1 | | | |
| 2 | 1 | 2 | 2 | | | |
| 3 | 1 | 3 | 3 | | | |
| 4 | 2 | 3 | 1 | | | |
| 5 | 2 | 1 | 2 | | | |
| 6 | 2 | 2 | 3 | | | |
| 7 | 3 | 2 | 1 | | | |
| 8 | 3 | 3 | 2 | | | |
| 9 | 3 | 1 | 3 | | | |

For calculation of signal-to-noise ratio (S/N Ratio) experiment data was gathered and then analysed. The S/N Ratio estimates the variance in the response in different

The postponement in looking for medical advice from a registered medical practitioner is tabulated I the Table -4.

| E-marin and Na | Delays (in Days) | | | | | | | |
|----------------|------------------|----|----|----|----|------|--|--|
| Experiment No. | 1 | 2 | 3 | 4 | 5 | Mean | | |
| 1 | 2 | 10 | 9 | 8 | 9 | 7.6 | | |
| 2 | 8 | 7 | 9 | 7 | 11 | 8.4 | | |
| 3 | 7 | 6 | 12 | 8 | 4 | 7.4 | | |
| 4 | 5 | 9 | 10 | 9 | 8 | 8.2 | | |
| 5 | 6 | 12 | 5 | 4 | 10 | 7.4 | | |
| 6 | 5 | 8 | 4 | 10 | 9 | 7.2 | | |
| 7 | 8 | 7 | 9 | 14 | 11 | 9.8 | | |
| 8 | 4 | 7 | 8 | 6 | 15 | 8 | | |
| 9 | 6 | 5 | 5 | 9 | 12 | 7.4 | | |

| Table 4. | Measured | Value | of | Delays | in | Seeking |
|----------|----------|---------|-----|--------|----|---------|
| | Med | dical A | dvi | ice | | |

noise conditions about the ideal or targeted value. The S/N Ratio for the nine experiments is listed in Table-5.

Table-5: S/N Ratio Calculation for Experiments

| Exp. No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|-----------|-------|--------|--------|--------|-------|-------|--------|--------|-------|
| S/N Ratio | -28.6 | -28.16 | -28.02 | -28.23 | -28.1 | -27.3 | -27.67 | -28.43 | -28.6 |

In the last but not the least, the full factorial analysis was conducted to show the validation of the result obtained through the Taguchi method. The result of the full factorial experiment is listed in the Table-6.

The optimum monthly interaction of drug, minimum adverse reaction and less time delay in seeking medical consultation is obtained from the experiment number 6, represented in Table -5, which contains highest S/N ratio as -27.30. The experimentation and S/N Ratio calculation output was then validated by conducting the full factorial

analysis experiment. The optimum condition for the parameters, namely, dangerous monthly drug interaction, adverse reaction, and delays in seeking medical advice, is met for the minimum mean value from the set of nine experiments that are conducted in the full factorial analysis (Table-6). The factor with the highest S/N Ratio must be selected as it shows the optimum result the mean value corresponding to experiment six is 6 is 6.66 which is also minimum among all experiments. Hence the result is verified using full factorial analysis.

| Exp. | | Mean | | |
|------|--|----------------------------|--|-------|
| No. | Dangerous drug Interaction (in months) | Adverse Reaction (in %) | Delays in seeking medical advice (in days) | |
| 1 | 11 | 7 | 11 | 9.66 |
| 2 | 5 | 9 | 9 | 7.66 |
| 3 | 13 | 6 | 8 | 9.00 |
| 4 | 8 | 10 | 6 | 8.00 |
| 5 | 9 | 4 | 12 | 8.33 |
| 6 | 10 | 5 | 5 | 6.66 |
| 7 | 14 | 3 | 6 | 7.66 |
| 8 | 7 | 5 | 14 | 8.66 |
| 9 | 15 | 8 | 8 | 10.33 |

Table-6: Full Factorial Analysis Experiment

Discussions

The study recommends that optimum monthly drug interaction is ten times per month with the home-made self-medication for treatment of mild diseases like fever. Along with it, up to five percent of the total percentage of the subjects considered for adverse reactions and five days of delay in seeking medical advice is the optimum condition in which people can rely on home-based selfmedication for the treatment of common diseases like a fever. The review of the extant literature suggest that selfmedication is just a transitory cure and not a lasting fix. Prolonged or heavy reliance on such home remedies for the treatment of complicated ailments may prove to be harmful to the overall health and wellness of people. The results of this study also concur that relying heavily on selfmedication can be detrimental for the overall health outcomes. The policy makers should devise policy for increasing awareness among rural population about the hazard associated with self-medication. The study suggests that use of telemedicine can help in solving the problem of availability of healthcare in rural India (Limaye et al., 2018, Mishra,2020). The policy makers should also think about alternate financing mechanism like health insurance or government financing to solve the problem of affordability of healthcare in rural India.

Limitations and Future Scope

The above study was carried out to investigate the practice of self-medication for mild disease like fever in rural more comprehensive study can be planned to investigate the self-medication in case of prevalent chronic disease like diabetes, asthma, and Tuberculosis. This study suggested telemedicine as a solution for solving the problem of availability of healthcare in India. A future study can be planned about the barriers for adoption of telemedicine in rural India. Other area of future research is optimization of allocation of healthcare resources in rural India.
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population in India. This research thus includes the survey

for home-based self-medication practices linked to the

treatment of a fever in the Indian state of Jharkhand only. A

References

- Abosede, O. (1984). Self-medication: An important aspect of primary health care. *Social Science & Medicine*, 19(7), 699-703
- Albatti, T., Alawwad, S., Aldueb, R., Alhoqail, R., & Almutairi, R. (2017). The self-medication use among adolescents aged between 13–18 years old; Prevalence and behavior, Riyadh – Kingdom of Saudi Arabia, from 2014–2015. *International Journal of Pediatrics and Adolescent Medicine*, 4(1), 19-25.

- Alhomoud, F., Aljamea, Z., Almahasnah, R., Alkhalifah, K., Basalelah, L., & Alhomoud, F. (2017). Self-medication and self-prescription with antibiotics in the Middle East—do they really happen? A systematic review of the prevalence, possible reasons, and outcomes. *International Journal of Infectious Diseases*, 57, 3-12.
- Azam, M., Rahman, Z., Talib, F., & Singh, K. (2012). A critical study of quality parameters in health care establishment. *International Journal of Health Care Quality Assurance*, *25*(5), 387-402.
- Cho, Y., & Cho, K. (2008). A loss function approach to group preference aggregation in the AHP. *Computers & Operations Research*, *35*(3), 884-892.
- Elizabeth Dorothy Sloand, Judith A. (2001). Selfmedication with common household medicines by young adolescents. *Issues in Comprehensive Pediatric Nursing*, 24(1), 57-67.
- Ghaderi, E., Hassanzadeh, K., Rahmani, K., Moradi, G., Esmailnasab, N., Roshani, D., & Azadnia, A. (2020). Prevalence of self-medication and its associated factors: a case study of Kurdistan province. *International Journal of Human Rights in Healthcare*, 13(3), 249-258.
- Isabel Tavares, A. (2013). Self-medication model and evidence from Portugal. *International Journal of Social Economics*, 40(11), 990-1009.
- Karimy, M., Rezaee-Momtaz, M., Tavousi, M., Montazeri, A., & Araban, M. (2019). Risk factors associated with self-medication among women in Iran. *BMC Public Health*, 19(1).
- Limaye, D., Limaye, V., Fortwengel, G., & Krause, G. (2018). Self-medication practices in urban and rural areas of western India: a cross-sectional study. *International Journal of Community Medicine and Public Health*, 5(7), 2672.

- Lofthouse, T. (1999). The Taguchi loss function. *Work-Study*, *48*(6), 218-223.
- Mishra, V. (2020). A Phased Approach for the Adaptation of Telemedicine in Diabetes Management. *Health Policy and Technology*, 9(1), 7-12.
- Mustafa, O., & Rohra, D. (2017). Patterns and determinants of self-medication among university students in Saudi Arabia. *Journal of Pharmaceutical Health Services Research*, 8(3), 177-185.
- Ocan, M., Obuku, E., Bwanga, F., Akena, D., Richard, S., Ogwal-Okeng, J., & Obua, C. (2015). Household antimicrobial self-medication: a systematic review and meta-analysis of the burden, risk factors, and outcomes in developing countries. *BMC Public Health*, *15*(1).
- Ong, K., Cheen, M., Chng, J., Chen, L., Ng, S., & Lim, S. et al. (2016). Effectiveness of a multidisciplinary home-based medication review program in reducing healthcare utilization among older adult Singaporeans. *Geriatrics & Gerontology International*, 17(2), 302-307.
- Pandey, D., Kulkarni, M., & Vrat, P. (2012). A methodology for simultaneous optimization of design parameters for the preventive maintenance and quality policy incorporating Taguchi loss function. *International Journal of Production Research*, 50(7), 2030-2045.
- Taner, T., & Antony, J. (2006). Applying Taguchi methods to health care. *Leadership in Health Services*, *19*(1), 26-35.
- Wang, X., Lin, L., Xuan, Z., Li, L., & Zhou, X. (2018). Keeping Antibiotics at Home Promotes Self-Medication with Antibiotics among Chinese University Students. *International Journal of Environmental Research and Public Health*, 15(4), 687.