Informatization of Intelligent Manufacturing to Green Innovation Reform of Tobacco Manufacturing Enterprises in the Era of Big Data

Junyi Shen, PhD
Kexin Bi, Professor
Wencan Zhuang, PhD
Jianbang Shi, PhD

Junyi Shen, Doctoral Candidate, Harbin University of Science and Technology, School of Economics and Management, Harbin Heilongjiang China. Kexin Bi, Supervisor of Doctoral Candidate, Professor, Harbin University of Science and Technology, School of Economics and Management, Harbin Engineering University;School of Economics and Management, Harbin Heilongjiang China. Wencan Zhuang, Doctoral Candidate, Harbin University of Science and Technology, School of Economics and Management, Harbin Heilongjiang China. Jianbang Shi, Doctoral Candidate, Harbin Engineering University, School of Economics and Management, Harbin Heilongjiang China. Correspondence Kexin Bi; 1610700008@stu.hrbust.edu.cn

Objectives: Based on intelligent manufacturing technology, this paper studies the informatization method of green innovation reform of tobacco manufacturing enterprises in the era of big data. **Methods:** By combing the literature at home and abroad, this paper expounds the technologies of data mining and data visualization based on the idea of lean management. On this basis, the basis of data management in the silk workshop of X tobacco enterprise is investigated and analyzed in detail from the aspects of human resources, equipment and management environment. Taking the blade feeder in the silk workshop of X cigarette factory as the research object, this paper establishes the self inspection model of equipment health state by using the weighted sum method of overall linearity and local nonlinearity. **Results:** The system can self check the health status of equipment and visually display the results. This method realizes timely and effective inspection and early warning of equipment health status. At the same time, the visual Kanban of workshop site management can provide production and equipment information to relevant personnel in time. This meets its demand for data visualization and changes the current situation of workshop data table display. **Conclusion:** This method reengineers the information business process of tobacco enterprises and establishes a new performance evaluation system. This effectively improves the existing management system of the workshop.

Key words: tobacco enterprise, green manufacturing, data visualization, business process.

At present, China is facing the economic problem of overcapacity. Therefore, the central government proposes to appropriately expand the total demand and improve the quality and efficiency of the supply system, so as to eliminate backward production capacity and help enterprises reduce costs, that is, supply side reform[1]. As for the tobacco industry, due to the great pressure of the global economic downturn, tax increase and favorable price of cigarette products and excessive tobacco control, the tobacco industry also needs to study the problem of improving supply side efficiency and carrying out in-depth supply side reform. In terms of equipment management, in recent years, the industrial automation

of cigarette enterprises has made great progress, established the bottom data acquisition, centralized control and condition monitoring systems, and also established a large number of application systems at the management level[2-3]. There are massive equipment data resources in these industrial automation systems and application systems, but the level of data management and data value mining in equipment management is not high, which leads to a waste of a large number of data resources and can not effectively support cigarette enterprises to realize lean management[4-5].

Advanced cigarette factories in the industry have done fruitful work in "lean management", which has effectively improved the lean management level of the industry. Yuxi cigarette factory actively constructs the "1346" lean production promotion model, and Shanghai cigarette factory actively promotes "the factory to explore and establish a production process and equipment coordination mechanism"[6]. In terms of equipment operation and maintenance, Qujing Cigarette Factory carries out 3D modeling of the equipment and virtual simulation of the production process by using 3D visualization technology[7]. Guided by the application of lean management concept, Baoji cigarette factory focuses on introducing three lean management tools, such as A3 report, visual Kanban and standardized inspection method[8]. Hangzhou cigarette factory is committed to the full life cycle management of cigarette production from the source of raw and auxiliary materials supply to the final consumption of cigarette products[9-10]. The lean management concept is introduced through "key technology and application of whole material single piece batch tracking and traceability supporting the whole cigarette supply chain"[11]. In the application of machine learning, Jinan cigarette factory uses neural network algorithm to model the production equipment, effectively simulate and simulate the production process, find out the impact of input parameters on the production

process, and realize the evaluation of process support ability[12]. It can be seen that enterprises in the industry have carried out a lot of useful work in lean management, but there are relatively few studies on data mining and visualization based on it.

METHODS
Introduction to Enterprise and Workshop

The predecessor of X cigarette factory of Shandong China Tobacco Industry Co., Ltd. is dongyulong tobacco company, which was founded in 1928[13]. It has a history of 87 years. X cigarette factory adheres to the corporate culture concept of "we are Mount Tai, we play a promising role", and implements the two strategies of "strengthening the factory with talents" and "strengthening the factory with culture"[14]. X cigarette factory is one of the backbone factories in the national tobacco industry with an annual output of more than 1 million boxes. The production pattern of "one coarse, one fine and one international" has a clear positioning and highlights. The enterprise has more than 1500 employees, including 61 senior technicians, 137 technicians, 4 provincial chief technicians, 6 municipal chief technicians, 2 chief technicians of Shandong Zhongyan, 2 provincial outstanding contribution technicians and 10 municipal outstanding contribution technicians. The enterprise has a technician workstation in Shandong Province, a chief technician workstation in Jinan and a model worker Innovation Studio[15]. In recent years, the enterprise has successively won the titles of "National May Day Labor Award", "national model worker's home", "national advanced collective in education and training in the Eleventh Five Year Plan" of the tobacco industry, and "Shandong Province Fumin Xinglu labor Award".

The silk workshop is subordinate to x cigarette factory of Shandong China Tobacco Industry Co., Ltd. as the basic processing workshop of cigarette products, it mainly undertakes the work of cut tobacco processing, dust removal and odor treatment. At present, the production organization of the silk workshop is scientific and standardized, the equipment layout is

clear, and the workshop environment is clean and bright. It has been gradually built into a modern cut tobacco product processing center of "management informatization, logistics modernization, control automation and process standardization", which can meet the processing and production of various flue-cured tobacco, export mixed and cigar cut tobacco. The workshop has 7 production lines, including 3 leaf silk production lines, 1 Stem Silk production line, 1 burley tobacco treatment line, 1 expansion silk production line and 1 thin slice silk production line, which can meet the processing and production of various flue-cured tobacco, export mixed and cigar cut tobacco, and has an annual production and processing capacity of 1.5 million cases of cigarette cut tobacco.

Brief Introduction To The Field Data Network Framework of Silk Workshop

The equipment data structure of the silk workshop adopts two-tier operation mode: on-site PLC data acquisition, "PLC computer" communication and data storage. In this way, each module is highly cohesive, and the degree of coincidence between modules is low, which is convenient for parallel implementation.
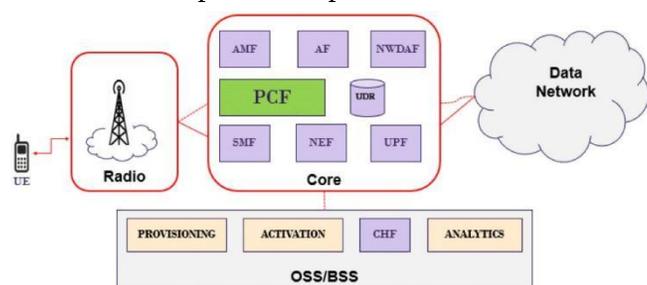

Figure 1 Device data management network architecture

The core of equipment data management is data, and the starting point is production site equipment data. This kind of data is generally scattered on each industrial computer and PLC site of the industrial control network, and the equipment operation database is deployed on the office network. Considering the need of network security, office network and industrial control network are physically isolated from each other, so there is an information barrier between the two networks. The silk workshop of X cigarette factory adopts the way of PLC bottom data mirror to realize the communication between the two networks. Siemens 1500 series PLC is deployed across networks, and PLC stations are connected across industrial control networks and office networks. A special transmission protocol is adopted between PLC and computer PC in the office network for data mirroring. The computer program reads the organized equipment data at the designated location to realize the data mirroring function. Because this method is realized by hardware and bottom data communication, the computer PC can not directly access the industrial control network and can not write data. Therefore, this method can not only realize large-scale data transmission, but also ensure the security of data transmission.

Equipment Data Mining Based On Customer Demand

Through the accumulation of condition based maintenance data under long-term equipment automatic detection, a machine to man system is established by using data visualization technology. In the equipment data mining based on customer demand, the changes of equipment performance indexes are drilled to the changes of equipment body state parameters at the next layer, and the main effects and interaction effects of equipment parameters are analyzed. From the past experience based maintenance mode to the dynamic, objective and quantitative equipment scientific maintenance strategy.

According to the maintenance strategy, continue to develop to science and intelligence, and carry out business process reengineering (BPR) with the help of information technology. In order to make the comprehensive equipment management persistent, standardized and lean, and follow the principle of "management needs, data can be taken and implementation can be implemented", a visual

equipment performance evaluation system with clear objectives, responsibility to people, objectivity and justice and closed-loop implementation is established, so as to realize the ability of independent management and self-restraint of employees.
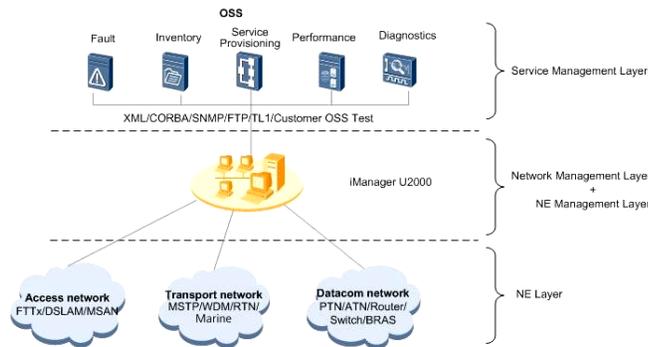

Figure 2 Equipment data management hierarchy

As a typical process industry, cigarette factory equipment management is an important link under the product quality and production process guarantee system of cigarette enterprises. In order to meet the product processing process indicators, a large number of equipment parameters are collected by various sensors. In order to provide quantitative analysis basis for equipment intelligent maintenance and intelligent management, we divide all equipment data according to data analysis direction and different use levels, and propose the division based on three dimensions of equipment evaluation, process support and production energy efficiency, and three levels of index system, index, parameter and data element. The specific dimensions and levels are as follows:
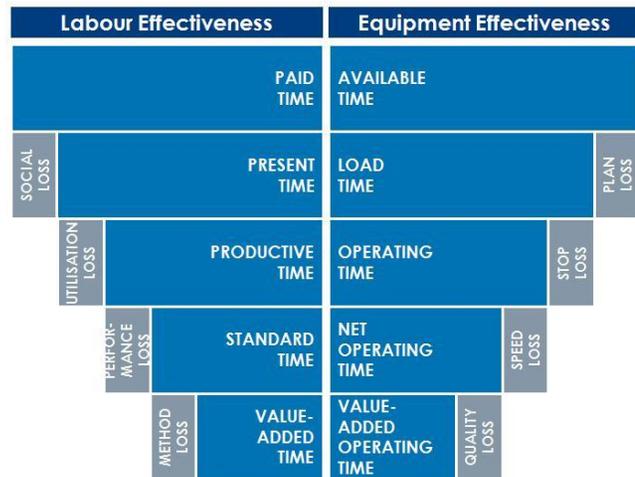

Figure 3 Equipment data hierarchy frame diagram

Quality Function Deployment (QFD) is a multi-level deductive analysis method that transforms customer or market requirements into design requirements, part characteristics, process requirements and production requirements. Today, QFD has received great attention from the international academic community, and the application field has slowly expanded from manufacturing to service industry, software development and other industries. In this paper, the function of QFD is expanded. According to the conclusion of the requirements analysis framework, the QFD analysis matrix designed by six sigma is used to analyze the data requirements of single equipment management. On the basis of equipment management analysis and demand classification, according to the characteristics of single equipment and management requirements, decompose the KPI index requirements related to posts to the underlying equipment data element.

Equipment management analysis requirements framework is the guidance of equipment data mining and application. Equipment data requirements analysis is the basis of equipment data mining and application. Equipment management analysis requirements are supported by equipment data. After determining the specific application direction, sort out the involved equipment data according to three aspects: production, process and equipment, which cover all data related to equipment management. Equipment data requirements

can be identified by post, and QFD analysis matrix is used to integrate analysis requirements and equipment data.

The QFD analysis matrix identifies the equipment data layer by layer. The first step is to establish the QFD matrix of user position and equipment indicators, and find the key indicators, analysis methods, application ways and the combination analysis relationship between indicators. The second step is to establish the QFD matrix of key indicators and equipment data elements, and find the key parameters, importance, implementation difficulty and the correlation between parameters.
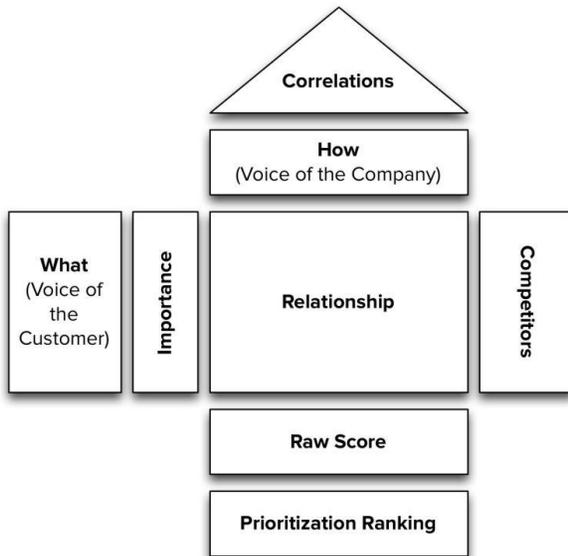

Figure 4 QFD analysis matrix

RESULTS
Equipment Health Status Self Inspection

Self-inspection model supports self-inspection by stages, which can be divided into four stages according to different working conditions of blade feeder, namely, startup stage, preheating stage, production stage and overall evaluation stage. The start-up stage is the stage before the 8K blade feeder starts up and runs, and the equipment operators run the power-on self-test at this stage. The

judgment parameter is Spice _Status_8K, and when this parameter is 0, it means that the equipment is not running. The preheating stage refers to the stage when the equipment is started up to meet the production requirements, and the equipment operators run the equipment preheating self-inspection at this stage.

The judgment parameters are Spice_Status_8K=2, before charging, the scale flow WBFIux_Spice_8K=0, the steam flow SteamFlux- 8Kspice>0, and the charging flow SpiceFlux_8K>0. The production stage is the stage of normal production and operation of equipment, and the equipment operators run the equipment production self-inspection at this stage. The judgment parameter is Spice Status 8K=4; Scale cumulative quantity > 50. In the overall evaluation stage, the state of the equipment in the whole batch production process is comprehensively evaluated, and the evaluation time point is when the flow rate of the front scale of the blade feeder is 0 at the end of production. (Production is not finished at this time). Evaluate the overall state of the equipment during the first three stages.

Data item scope formulation method:

(1) Determination of center value:

The central value of process evaluation parameters is set according to the process standard, other numerical values are set by the statistical mean value under the healthy state of the equipment, and the Boolean value is determined by the correct state value.

(2) Threshold determination:

The process evaluation parameters are set according to the process standard, other numerical values are set with 95% confidence interval, and the Boolean threshold is 0.

The data obtained by statistical method shall be processed separately according to the stage. The statistical batch shall exceed 5 batches, and the batches shall be relatively scattered, covering multiple product brands of the production line.

The specific statistical methods are as follows: (1) Multiple batches of data at corresponding stages are extracted and sorted out uniformly. (2) Calculate the

mean and median of each parameter according to the parameters of the sorted data, and one of the mean and median can be used as the central value. (3) Sort the sorted data according to the parameters, and set the upper and lower limits of the parameters according to the requirements of the value range.

Data Visualization Kanban

Kanban design principles:

(1) Problem oriented principle: data visualization is to solve the problem that data is difficult to be intuitively understood and used in the real work process. Therefore, the principle of problem orientation must be taken in the design process. Abandoning problems to talk about design is seeking fish out of trees, which will cause artificial communication obstacles in the process of practical application, and even fail to realize the practical application of data visualization. The problems existing in reality can not be solved. Taking the problem as the traction, the problem design scheme can be targeted and avoid making cars behind closed doors.

(2) Pay attention to the principle of data comparison: the vast majority of various production and production related equipment and process data in the silk workshop have strict numerical requirements to meet the requirements of product qualification. The comparison between real-time operation data and standard data is very important. Through the comparison, the problem point can be found in time to avoid the occurrence of nonconforming products. In addition, there are comparative requirements in management, such as the quality of products produced by different operators, the change of equipment consumption data, etc. Therefore, the principle of data comparison should be paid attention to in the process of data visualization design.

(3) Principle of intuitiveness and conciseness of graphics: the purpose of data visualization is to vividly

show the changes of data to the audience in the form of graphics and tables. Being able to obtain the information they want at the first time is the fundamental principle of data visualization design. Therefore, when selecting graphics, we should pay attention to the principle of intuition and simplicity of graphics to avoid making the design graphics difficult to understand.

(4) Principles of human-computer interaction and guidance: there are many levels of data that need to be displayed in data, different positions of the audience, and different types of data. Therefore, attention should be paid to the needs of human-computer interaction in the design. Through good human-computer interaction, the use needs of different people can be met, and the audience can be actively guided to use, which is conducive to promotion. Therefore, in the design process, we should pay attention to the principles of man-machine interaction and guidance.

According to the needs of production operation and on-site management, the visual Kanban in the silk workshop mainly shows four main modules: fault analysis, process quality, equipment efficiency and batch management. The indicators displayed in each module are selected according to the previous data resource list, QFD analysis and other data mining methods. All data elements are from the real-time data in the workshop equipment operation database.

The data visualization Kanban is designed in strict accordance with the design principles to meet the practical application needs of the workshop. In terms of users, due to the different indicators that field operators and managers need to pay attention to, field operators need to pay attention to the real-time data of moisture at the outlet of silk dryer, while managers need to pay attention to batch qualification rate and other information. Therefore, the Kanban designs the entrance for different users, which also shows the information they need to pay attention to.

Establish Equipment Performance Evaluation System Based On Data Visualization

(1) Performance evaluation of model aircraft

The selection of "model machine" can stimulate the work enthusiasm of the majority of employees, create a good atmosphere of "officer entrepreneurship", and fully mobilize the enthusiasm of the majority of employees to learn technology, learn knowledge, practice skills and compare their contributions. Encourage employees to improve their skills and become talents in their posts, accelerate the selection and training of skilled talents through multiple channels and channels, and cultivate and bring up a skilled talent team with excellent quality and skills.

(2) Performance evaluation of excellent maintenance workers

According to the area in charge of the repairman, the silk workshop conducts performance evaluation from six aspects: equipment failure rate, output contribution rate, process quality, technological innovation, democratic evaluation and others, and maintenance cost, accounting for 30%, 10%, 20%, 10%, 20% and 10% respectively.

According to the equipment, the silk making workshop is divided into 2K leaf making, 2K silk making, 6K leaf making, 6K silk making, 8K leaf making, 8K silk making, 3K tobacco stem, 3K stem silk, expansion silk, silk making dust removal (including odor treatment and purified water equipment), roll bag dust removal (including sheet pretreatment) and other attached equipment.

(3) Implementation effect

After the implementation of the new performance evaluation system in the silk workshop, the rationality, transparency and standardization of staff work evaluation have been effectively improved. The workshop staff have obvious incentive response to the new performance evaluation system, the fault handling efficiency has been improved, and the craftsmanship spirit of employees has been significantly improved. Compared with 2014, the annual downtime, downtime rate, unplanned downtime and unplanned downtime of the silk workshop in 2015 decreased significantly. Compared with 2014, the equipment failure rate decreased by 17.71%.

The new performance evaluation system has also promoted the development of workshop innovation, formed a multi-level innovation path of employee participation and improvement, team collective tackling key problems and win-win cooperation of technical alliance, and promoted the steady improvement of equipment management level. In 2014, more than 700 rationalization suggestions were actively submitted, with an average of 2 per person, more than 200 minor changes were completed, and more than 20 advanced working methods emerged. Six Six Sigma projects, 35 QC projects and 45 innovative achievements have been completed, many of which have won provincial and national awards. The employee participation rate is also rising, and the innovation atmosphere is becoming stronger and stronger.

DISCUSSION

The global economy is generally in a weak state, and China's economic growth rate has been reduced to less than 8%. In order to improve the national economic operation efficiency and eliminate backward production capacity, the state recently proposed "supply side structural reform" to improve the quality of economic operation. As an important part of the national economy, the tobacco industry also has various problems on the supply side. Therefore, the supply side reform also has important guiding significance for the development of the tobacco industry. Cigarette factories should start from improving supply quality on the one hand, and improve total factor productivity on the other hand.

There are a large number of equipment data resources in the industrial automation system and application system of cigarette factory, but the level of data management and data value mining in equipment management is not high, which leads to a waste of a large number of data resources and can not effectively support cigarette enterprises to realize lean management. At the same time, through the establishment of equipment health self-test model and data visualization, the mined data are applied tentatively, and good results are obtained. Finally, this paper reengineers the maintenance mode according to

the data visualization technology, and establishes the equipment performance evaluation system based on data visualization. Data mining was carried out in the silk workshop, and the visualization research based on it successfully showed the equipment data to the managers, technicians and operators with use needs, so that they had a more intuitive, convenient and reliable understanding of the management process, product quality and equipment status.

At present, a large number of chaotic data are gathered in tobacco enterprises, but there are no mining practices and reliable methods, and even individual units have no mining meaning, not to mention the visual display and application of it to the daily operation, management and production of enterprises. If data wealth is not effectively utilized, it often becomes data garbage. Data mining and data visualization can help enterprise leaders better manage their enterprises. Once most people begin to recognize the value of data, controlling and analyzing data is only a means and tool for current work. Big data is a representation or extension of the development to the current stage driven by the Internet. Driven by emerging technologies represented by intelligent sensing technology, networking technology, Internet of things and neural network decision-making, the underlying data of these devices began to be mined and displayed to users through data visualization technology. This will provide beneficial practice for state-owned enterprises in implementing the central supply side reform, which can effectively improve the production efficiency of state-owned enterprises, better cultivate the craftsman spirit of employees, reflect the needs of market customers more flexibly, and promote state-owned enterprises to participate in global market-oriented competition more deeply.

Conflicts of Interest Disclosure Statement

The authors declare no conflict of interest in the authorship or publication of this work. The authors declare no sponsored financial sources by any organization related to tobacco production for the undertaken study.

References

1. Ackert K, Brock B, Friedrichsen S C, et al. Countering tobacco industry tactics on the economic costs of restricting menthol tobacco. Tobacco Control, 2020:tobaccocontrol-2020-055737.
2. Galiatsatos P, Brigham E, Krasnoff R, et al. Association between neighborhood socioeconomic status, tobacco store density and smoking status in pregnant women in an urban area. Preventive Medicine, 2020, 136:106107.
3. Oates G R, Baker E, Rowe S M, et al. Tobacco smoke exposure and socioeconomic factors are independent predictors of pulmonary decline in pediatric cystic fibrosis. Journal of Cystic Fibrosis, 2020, 19(5).
4. A González-Roz, Jackson J, Murphy C, et al. Behavioral economic tobacco demand in relation to cigarette consumption and nicotine dependence: a meta-analysis of cross-sectional relationships. Addiction, 2019, 114.
5. Waa A, Robson B, Gifford H, et al. Foundation for a Smoke-Free World and healthy Indigenous futures: an oxymoron?. Tobacco Control, 2020, 29(2):237.
6. Zuhal Akyürek. LMDI decomposition analysis of energy consumption of Turkish manufacturing industry: 2005–2014. Energy Efficiency, 2020, 13(8).
7. J Coughlan, Shah S . The impact of Brexit on oral health. British Dental Journal, 2020, 229(9):622-626.
8. Cao W, Hecht S S, Murphy S E, et al. Analysis of Multiple Biomarkers Using Structural Equation Modeling. Tobacco Regulatory Science, 2020, 6(4):266-278.
9. D'Angelo H, Ayala G X, Gittelsohn J, et al. An Analysis of Small Retailers' Relationships with Tobacco Companies in 4 US Cities. Tobacco Regulatory Science, 2020, 6(1):3-14.
10. Na´fra´di L, Nakamoto K, Schulz PJ. Is patient empowerment the key to promote adherence? A systematic review of the relationship between self-efficacy, health locus of control and medication adherence. PLoS ONE. 2017;12(10):e0186458.
11. Açıkgöz Çepni S, Kitiş Y. Relationship between healthy lifestyle behaviors and health locus of control and health-specific self-efficacy in university students. Jpn J Nurs Sci. 2017;14(3):231-239.
12. Hossaini FA, Sharifi N, Dowlatkhah HR. Compare health promoting behaviors and health locus of control in medical and non-medical students in 2017. Jmj. 2018;16(3):25-32.
13. Kurtović A, Vuković I, Gajić M. The effect of locus of control on university students' mental health: possible mediation through self-esteem and coping. J Psychol Interdiscip Appl. 2018.
14. Jain M, Singh S. Locus of control and its relationship with mental health and adjustment among adolescent females. J Mental Health Hum Behav. 2015;20:16-21.
15. Makowska M, Boguszewski R, Nowakowski M, Podkowińska M. Self-medication-related behaviors and Poland's COVID-19 lockdown. Int J Environ Res Public Health 2020;17:8344.