Prognosis of efficacy of medical and social rehabilitation in disabled individuals with respiratory diseases

Bezsmertnyi, Yurii, Shevchuk, Viktor, Pavlov, Sergii, Zlepko, Sergii, Kurylenko, Iryna, et al.

Yurii O. Bezsmertnyi, Viktor I. Shevchuk, Sergii V. Pavlov, Sergii M. Zlepko, Iryna V. Kurylenko, Halyna V. Bezsmertna, Marcin Maciejewski, Alina Bugubayeva, "Prognosis of efficacy of medical and social rehabilitation in disabled individuals with respiratory diseases," Proc. SPIE 11176, Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments 2019, 1117633 (6 November 2019); doi: 10.1117/12.2537340

SPIE.

Event: Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments 2019, 2019, Wilga, Poland

Prognosis of efficacy of medical and social rehabilitation in disabled individuals with respiratory diseases

Yurii O. Bezsmertnyi*[a], Viktor I. Shevchuk [a], Sergii V. Pavlov [b], Sergii M. Zlepko [b], Iryna V. Kurylenko [a], Halyna V. Bezsmertna [a], Marcin Maciejewski [c], Alina Bugubayeva [d]
[1]Scientific Research Institute of Invalid Rehabilitation on the base of Vinnitsa Pirogov National Medical University; [b]Vinnytsia National Technical University, 95 Khmelnytske Shose, Vinnytsia 21021, Ukraine; [c]Lublin University of Technology, Nadbystrzycka 38A, 20-618 Lublin, Poland; [d]East Kazakhstan State Technical University named after D.Serikbayev, A.K. Protozanov Street 69, 070004 Ust-Kamenogorsk, Kazakhstan

ABSTRACT

On the basis of the created mathematical model prognostically significant measures of medical and social rehabilitation in persons with disabilities with pathology of respiratory organs were determined. The main prognostic significance characteristics of the "effectiveness" of rehabilitation were established and the influence of different types of rehabilitation on the process of recovery and (or) improving livelihoods was estimated. The main rehabilitation measures that increase the effectiveness of rehabilitation in persons with disabilities due to broncho-pulmonary diseases are: "medical observation", "restorative therapy", "spa treatment" and all the measures recommended in the individual rehabilitation program "labor" and "physical rehabilitation", "Examination of potential professional abilities", "vocational training, retraining and advanced training".

Keywords: prognostic model, individual rehabilitation program, rehabilitation, disabilities respiratory diseases

1. INTRODUCTION

Respiratory diseases are on the fourth position among mortality causes in the world, leading to considerable limitations in daily living activities and presenting serious medical, economic and social problems for the society [1, 2]. Because of that, a large number of recent works have been devoted to study and development of "pulmonary rehabilitation" [3, 4, 5]. Provision of rehabilitation services for disabled individuals are done according to Individual Rehabilitation Programs (IRP), their main principle is an integrated approach considered on specific physiological and psychopathological disorders caused by underlying and concomitant diseases. An increased number of individuals with special needs due to respiratory diseases has become a stimulus to analyze efficacy of individual rehabilitation programs of pulmonary patients and to determine the priority directions in rehabilitation [6,7,8].

The purpose of the study was to determine prognostically significant measures of medical and social rehabilitation of disabled individuals with respiratory diseases, which would improve the efficacy of rehabilitation process, by mathematical modeling method.

2. OBJECT AND METHODS OF STUDY

IRPs of 15434 disabled individuals with pathology of respiratory organs from 22 regions of Ukraine were analyzed (ICD-10 codes: J 00 – J 99).The ratio percentage of patients by age was the following: 35.4% – young, 59.04% – middle-aged, 5.56% – elderly. All study individuals had limited capacity to work (79.11% – I degree, 19.58 – II degree, 1.31% – III degree), 82.5% – limited ability to walk (81.0% – I degree, 18.0% – II degree, 1.0% – III degree), 68.12% – limited activities of daily living (75.31% – I degree, 23.36 – I degree, 1.33 – II degree) [9,10,11].

IRPs (2012-2014) were evaluated in dynamics for three years. The study was conducted by 49 parameters of medical, psychological and pedagogical, physical, professional, vocational, physical culture and sport, social and household

* bezsmertnyiyurii@gmail.com

Photonics Applications in Astronomy, Communications, Industry, and High-Energy Physics Experiments 2019, edited by Ryszard S. Romaniuk, Maciej Linczuk, Proc. of SPIE Vol. 11176, 1117633
 · doi: 10.1117/12.2537340

rehabilitation, provision with rehabilitation equipment and medical products [12,13,14].

A multivariate linear discriminant of Fisher's analysis was performed to determine the priority parameters and to develop prognostic model. The general model of multivariate regression was (1):

$$Y = a_0 + a_1x_1 + a_1x_1 + \cdots + a_{48}x_{48} + a_{49}x_{49} \quad (1)$$

where *y* is the indicator of innovation effectiveness (rehabilitation); x_1, x_2, x_3, ..., x_{48}, x_{49} are the factors influencing the performance indicator; a_0 is the constant index, independent of impact factors; a_1, a_2, a_3, ..., a_{48}, a_{49} are the multivariate regression coefficients.

The parameters were evaluated by calculating Wilks' Lambda variables, analyzing the received system of classification equations and the model adequacy. The indicator "life activity restoration" of a disabled person within 1 year of compiling IRP was used as the endpoint. Grading of the variable "life activity restoration" was done according to IRP form: "complete restoration of life activity", "partial restoration of life activity", "no restoration of life activity", "increased limitation of life activity" [15,16].

3. RESULTS OF THE RESEARCH AND DISCUSSION

Using the method of multivariate linear discriminant analysis, regression coefficient vector was determined and linear regression model regarding the indicator of life activity restoration in disabled patients with respiratory diseases was created (2).

$$Y(x) = \begin{pmatrix} \begin{bmatrix} 0 \\ 0.56 \\ 0.27 \\ 0.02 \\ 0.38 \\ 0.02 \\ 0.02 \\ 0.87 \\ 0.21 \\ 0.09 \end{bmatrix} & \begin{bmatrix} 0.06 \\ 0 \\ -0.01 \\ 0 \\ 0.36 \\ 0.04 \\ 0.13 \\ 0.25 \\ 0.27 \\ 0.15 \end{bmatrix} & \begin{bmatrix} -0.01 \\ -0.01 \\ 0.13 \\ -0.02 \\ 0.31 \\ 0.76 \\ 0.51 \\ -0.05 \\ -0.01 \\ 0.03 \end{bmatrix} & \begin{bmatrix} 0 \\ 0 \\ 0.01 \\ 0.2 \\ 0 \\ 0.02 \\ 0 \\ 0.01 \\ 0 \\ 0 \end{bmatrix} & \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0.01 \\ 0 \end{bmatrix} \end{pmatrix} \quad (2)$$

It is noteworthy that direction of regression coefficient vectors by the majority of parameters was positive, only 6 of 49 evaluated parameters predicted negative influence on "life activity restoration" (*Y(x)*) (3). Correspondingly, linear regression model for disabled individuals due to respiratory pathology was the following [17,18,19]:

$$\begin{aligned} Y(x) = {} & 0 + 0.56x_1 + 0.27x_2 + 0.02x_3 + 0.38x_4 + 0.02x_5 + 0.02x_6 + 0.87x_7 + 0.21x_8 + 0.09x_9 + \\ & + 0.06x_{10} + 0x_{11} - 0.01x_{12} + 0x_{13} + 0.36x_{14} + 0.04x_{15} + 0.13x_{16} + 0.25x_{17} + 0.27x_{18} + 0.15x_{19} - \\ & - 0.01x_{20} - 0.01x_{21} + 0.13x_{22} - 0.02x_{23} + 0.31x_{24} + 0.76x_{25} + 0.51x_{26} - 0.05x_{27} - 0.01x_{28} + 0.03x_{29} + \\ & + 0x_{30} + 0x_{31} + 0.01x_{32} + 0.2x_{33} + 0x_{34} + 0.02x_{35} + 0x_{36} + 0.01x_{37} + 0x_{38} + 0x_{39} + \\ & + 0x_{40} + 0x_{41} + 0x_{42} + 0x_{43} + 0x_{44} + 0x_{45} + 0x_{46} + 0x_{47} + 0.01x_{48} + 0x_{49} \end{aligned} \quad (3)$$

where:

Medical rehabilitation: x_1 – restorative therapy, x_2 – preventive measures, x_3 – reconstructive surgery, x_4 – health resort treatment, x_5 – phychiatric support, x_6 – hearing prosthetics, x_7 –medical screening.

Psychological and pedagogical rehabilitation: x_8 – counseling services, x_9 –psychological and pedagogical diagnosis, x_{10} – psychological and pedagogical correction, x_{11} – educational services, x_{12} – collective form of training including mainstreaming and inclusive training, x_{13} – individual studies.

Physical rehabilitation: x_{14} – counseling services, x_{15} – ergotherapy, x_{16} – kinesitherapy, x_{17} – massage therapy, x_{18} – exercise therapy.

Professional rehabilitation: x_{19} – examination of potential professional abilities, x_{20} – professional orientation, x_{21} – professional selection, x_{22} – vocational training, retraining and advanced studies, x_{23} – vocational education.

Vocational rehabilitation: x_{24} – creation of work place and its adaptation in terms of safety and special needs for a disabled person, x_{25} – rational employment (renewal of work activity of a disabled person in previous or new career, x_{26} – types of professions and specialties suitable for health reasons.

Physical training and sport rehabilitation: x_{27} – instruction in physical training skills, x_{28} – health improvement and rehabilitation in physical culture and sports camps for disabled, x_{29} – training lessons in physical culture and sport, x_{30} – sport activities.

Social and home rehabilitation: x_{31} – furniture adjustment, installation of equipment for adaptation of living accommodations, x_{32} – social home nursing, x_{33} – occupational therapy.

Technical and other means of rehabilitation: Means of transport: x_{34} – wheelchairs of various types, x_{35} – sticks, x_{36} – crutches, x_{37} – supportive walking aids.

Special aids for orientation, communication and information exchange: x_{38} – mobile telephones for written communication, faxes and other surdotechnical aids.

Special aids for activities of daily living: x_{39} – supportive household appliances.

Special aids for nursing: x_{40} – supportive toilet aids, x_{41} – supportive aids for rising, x_{42} – wheel-chairs with sanitary facilities.

Special aids for education and employment: x_{43} – special furniture.

Prosthetic devices: x_{44} – orthopedic items, x_{45} – orthopedic shoes, x_{46} – special clothes.

Medical products: x_{47} – endoprostheses and other medical products according to the standards, x_{48} – hearing aids, x_{49} – teeth and jaw prostheses.

According to the data received, all methods of medical rehabilitation in patients with diseases of respiratory organs had positive effect on the ultimate result of rehabilitation. At the same time, it should be noted that such parameters as “medical screening”, “restorative therapy” and “health-resort therapy” took the priority positions in improving rehabilitation efficacy. These types of rehabilitation process in patients with bronchial and pulmonary diseases are expected to be helpful in reaching control over the course of the disease, including both prevention of exacerbation recurrences, and observance of optimal compliance with basic therapy and promotion of appropriate mode of life.

Similarly, though statistically less significant data were obtained for parameters of “physical rehabilitation”. For example, “counseling in physical rehabilitation”, “kinesitherapy”, “ergotherapy”, “massage therapy” and “exercise therapy” were determined as prognostic factors of “increase/restoration of limited life activity” in individuals with pathology of respiratory organs.

Two out of five parameters of “professional rehabilitation” were referred to the methods of “positive” influence: “examination of potential professional abilities” and “vocational training, retraining and advanced studies”. And vice versa, implementation of all stages of “vocational rehabilitation” significantly predicted the increase or restoration of limited life activity in disabled individuals due to bronchial and pulmonary diseases.

The parameters studied were insignificant, though they were determined by the model as having prognostic value concerning improvement of rehabilitation efficacy. Many parameters of “psychological and pedagogical rehabilitation”, “lessons in physical training and sport rehabilitation”, “social home nursing”, “supply with sticks” and “supportive walking aids” are among them.

Therefore, the study enabled to determine the major prognostically significant characteristics of rehabilitation “efficacy” and at the same time to reveal their specific aspects in disabled individuals with pathology of respiratory organs. In particular, taking into account positive direction of regression coefficient vectors by the majority of parameters (90.2%), relatively low values of the coefficients themselves (not exceeding 1.0) and their minimal discrepancies, a conclusion can be made that impact of different types of rehabilitation on the process of restoration or increase of life activity in disabled individuals with pathology of respiratory system is integrated, multifactor and equally important.

In order to check the significance of the equation and its coefficients, statistical analysis of the obtained regression equation was performed (Table 1). For unbiased estimation of variance, the following calculations were done:

Unbiased error $\varepsilon = Y–Y(x) = Y–X \cdot S$.

Mean approximation error: $A = \frac{\sum\left|\frac{\varepsilon}{Y}\right|}{n}100\% = \frac{0,4072}{5}100\% = 8,14\%$.

Estimation of dispersion: $s_e^2 = \left(Y - X \cdot Y(x)\right)^T \cdot \left(Y - X \cdot Y(x)\right) = 73578,82.$

Unbiased estimation of variance: $s^2 = \left|\frac{s_e^2}{n-m-1}\right| = 1548,86$.

Estimation of standard error of the mean (*standard error in Y assessment*): $S = \sqrt{s^2} = 39,36$.

Table 1. Results of calculations of intermediate parameters to check Fisher's F-criterion

Y	$Y(x)$	$\varepsilon = Y - Y(x)$	ε^2	$(Y(x)–Y_{cp})^2$	$\left\|\frac{\varepsilon}{Y}\right\|$
751.95	826.32	–74.37	5530.90	31086.63	0.0989
1016.67	1093.19	–76.52	5855.31	7815.62	0.0753
564.5	600.54	–36.04	1298.88	132324.25	0.0638
1115.5	1014.09	101.41	10283.99	35057.32	0.0909
1026.85	1107.18	–80.33	6452.91	9719.20	0.0782
			29421.99	216003.01	0.4072

The degree of combined influence of parameters on the ultimate result was evaluated by multiple correlation index, its value being 0—1. R was used to interpret the direction of correlation. The more closely actual y_i values were located with relation to regression line, the less residual variance was and, hence, the greater value of Ry (x_1, ... , x_m). Accordingly, when the value of R approximated 1, the regression equation reflected actual data better, and the factors had stronger influence on the result. In the value of R approximating 0, the regression equation reflected actual data badly, and the factors had weak influence on the result.

$$R = \sqrt{1 - \frac{s_e^2}{\sum\left(y - y_{cp}\right)^2}} = \sqrt{1 - \frac{73578,82}{216003,01}} = 0,81201.$$

Strong relationship between factors Y and X was found.

Significance of multiple regression equation was evaluated by checking the hypothesis stating that determination coefficient, calculated by general population data, is equal to zero. Fisher's F-criterion was used for this purpose.

$$R^2 = 0.65936,$$

$$F = \frac{R^2}{1-R^2}\frac{n-m-1}{m} = \frac{0.65936}{1-0.65936}\frac{49-5-1}{5} = 16.6466$$

$$F_{cr} = 2.4$$

Since the actual value of $F > F_{cr}$, determination coefficient is statistically significant, the validity of express-model is confirmed by mathematical and statistical methods.

Thus, correlation multivariate regressive analysis made it possible to characterize the nature of existing relationships in mathematic model, namely to determine functional dependence of the parameter "restoration of life activity" (Y) on factors affecting Y studied rehabilitation measures(x_{1-49}).

4. CONCLUSIONS

1. Prognosis of the end point ("restoration of life activity") in disabled individuals due to pathology of broncho-pulmanory system should be based on multivariate statistical model considering 49 major parameters in compiling IRP.
2. An influence of different types of rehabilitation on the process of restoration or an increase of life activity in disabled individuals due to pathology of respiratory system is integrated, multifactor and equally important.
3. According to multivariate stepwise discriminant analysis, major rehabilitation measures increasing rehabilitation efficacy in disabled individuals due to pathology of broncho-pulmanory system are the following: "medical screening", "restorative therapy" and "health-resort treatment", all recommended by IRP measures of "vocational" and "physical rehabilitation", "examination of potential professional abilities", "vocational training, retraining and advanced studies". Integrated rehabilitation of disabled individuals with pulmonary diseases will contribute to restoration of their life activity and ultimately will provide the success of rehabilitation measures.

REFERENCES

[1] Global Initiative for Chronic Obstructive Lung Disease. Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Pulmonary Disease. Revised (2018). https://goldcopd.org/wp-content/uploads/2018/02/WMS-GOLD-2018-Feb-Final-to-print-v2.pdf.

[2] Vogelmeier, C.F., Criner, G.J., Martinez, F.J., et al., "Global Strategy for the Diagnosis, Management and Prevention of Chronic Obstructive Lung Disease, 2017 Report: GOLD Executive Summary," Respirology 22(3), 575-601 (2017).

[3] Engel, R.M., Wearing, J., Gonski, P., Vemulpad, S., "The effect of combining manual therapy with exercise for mild chronic obstructive pulmonary disease: study protocol for a randomised controlled trial," Trials 18(1), 282 (2017)

[4] Wada, J.T., Borges-Santos, E., Porras, D.C., et al., "Effects of aerobic training combined with respiratory muscle stretching on the functional exercise capacity and thoracoabdominal kinematics in patients with COPD: a randomized and controlled trial," Int J Chron Obstruct Pulmon Dis. 11, 2691-2700(2016).

[5] McCarthy, B., Casey, D., Devane, D., et al., "Pulmonary rehabilitation for chronic obstructive pulmonary disease," Cochrane Database Syst Rev. 2, CD003793 (2015).

[6] Watz, H., Waschki, B., Meyer, T., Magnussen, H., "Physical activity in patients with COPD," Eur. Respir. J. 33(2), 262–272 (2009).

[7] Vysotska, O.V., Nosov, K., Savina, N.B., et al., "An approach to determination of the criteria of harmony of biological objects," Proc. SPIE 10808, 108083B (2018).

[8] Pavlov, S.V., Kozhukhar, A.T., et al., "Electro-optical system for the automated selection of dental implants according to their colour matching," Przeglad Elektrotechniczny 93(3), 121-124 (2017).

[9] Kholin, V.V., Chepurna, O.M., Pavlov, S.V., et al., "Methods and fiber optics spectrometry system for control of photosensitizer in tissue during photodynamic therapy," Proc. SPIE 10031, 1003138 (2016).

[10] Rovira, R.H., Tuzhanskyy, S.Ye., Pavlov, S.V., Savenkov, S.N., Kolomiets, I.S., et al., "Polarimetric characterisation of histological section of skin with pathological changes," Proc. SPIE 10031, 100313E (2016).

[11] Pavlov, S.V., Vassilenko, V.B., Saldan, I.R.,Vovkotrub, D.V., Poplavskaya, A.A., et al., "Methods of processing biomedical image of retinal macular region of the eye," Proc. SPIE 9961, 99610X (2016).

[12] Rovira, R., Bayas, M.M., Pavlov, S.V., Kozlovskaya, T.I., Kisała P., et al., "Application of a modified evolutionary algorithm for the optimization of data acquisition to improve the accuracy of a video-polarimetric system," Proc. SPIE 9816, 981619 (2015).

[13] Zabolotna N.I.; Pavlov S.V.; Radchenko K.O.; Stasenko V.A.; Wójcik W., et al. Diagnostic efficiency of Mueller-matrix polarization reconstruction system of the phase structure of liver tissue, Proc. SPIE 9816, Optical Fibers and Their Applications 2015, 98161E (2015).

[14] Avrunin O.G.; Tymkovych M.Y.; Pavlov S.V.; Timchik S.V.; Kisała P., et al. Classification of CT-brain slices based on local histograms, Proc. SPIE 9816, Optical Fibers and Their Applications 2015, 98161J (2015).
[15] Chepurna, O.M., Shton I.; Kholin V.; Voytsehovich V.; Popov V., et al. Photodynamic therapy with laser scanning mode of tumor irradiation, Proc. SPIE 9816, Optical Fibers and Their Applications 2015, 98161F (2015).
[16] Wójcik,W. and Smolarz, A., [Information Technology in Medical Diagnostics], Taylor & Francis Group CRC Press Reference, London, (2017).
[17] Dzierżak,R., MichalskaM., "Analysis of the effectiveness of selected segmentation methods of anatomical brain structures," Informatyka, Automatyka, Pomiary w Gospodarce i Ochronie Srodowiska -IAPGOS 8(2), 58-61 (2018).
[18] Vassilenko, V., Valtchev, S., Teixeira, J. P. and Pavlov, S., "Energy harvesting: an interesting topic for education programs in engineering specialities," Proc. Internet, Education, Science, 149-156 (2016).
[19] Kvyetnyy R., Sofina, O., Orlyk, P., Utreras A. J., Smolarz, A., Wójcik, W. and Orazalieva, S., "Improving the quality perception of digital images using modified method of the eye aberration correction," Proc. SPIE 10031, 1003113 (2016).