DOI 10.32782/city-development.2024.3-16
UDC 564.75.05:057.1-056.22:616.002.7

REPRODUCTIVE HEALTH OF MEN WITH CHRONIC INFLAMMATION OF THE UROGENITAL TRACT

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Summary. The aim of the study was to statistically evaluate the impact of chronic inflammation of the urogenital tract and other related factors on men's reproductive health, as well as predicting the likelihood of future health. The study was implemented in several successive stages. In the first stage, a system of key indicators of the impact on men's reproductive health due to the transfer of chronic inflammation of the urogenital tract (CIUT) was developed by expert interrogation of family doctors, dermatovenereologists, urologists. In the second stage, information on key factors of influence was collected by interviewing men during 2021-2024 by the face-to-face method during the admission of patients to the clinical bases of the Department of Family Medicine and outpatient care at the NMAPE named after P.L. Shupik. 422 patients participated in the survey. In the third stage, on the basis of the formed database of the interviewed patients, the correlation between the reproductive health indicator of men with CIUT and the main factors that determine it is established. In the next stage, factor variables were identified and prognostic models of the probability of fertility decline among men with CIUT were constructed. The system of key indicators for the impact on men's reproductive health due to the transfer of CIUT is grouped into five blocks: socio-demographic characteristics; history of sexual system diseases; maintaining a healthy lifestyle; features of sexual life; actual semen parameters. The greatest impact on the negative reproductive health of men who have a history of stroke has demographic characteristics of patients and sperm parameters. Thus, men over 40 years of age with a pathological sperm morphotype are more likely to have a decrease in fertility in the background or after treatment with CIUT. In the course of the experimental calculations, it was found that the most appropriate approach in identifying the factors influencing the future reproductive health of men is to use linear prognostic models using structural variables. When constructing a prognostic model of men's reproductive health, it was determined that the model was more adequate when combining the factors of each of the five indicator blocks. As a result of identifying the most important factor variables for their further use in the prognostic models of men's reproductive health, a stepwise regression method with "joining" and "exclusion" was applied.

Keywords: reproductive health, chronic inflammation of the urogenital tract of male, mathematical modeling.

Relevance of the issue. The issue of promoting and preserving human health is the most important task of today, which is provided by comprehensive and integrated services of comprehensive, continuous and patient-centered primary care that is demonstrated in achieving the best results based on scientific knowledge and principles of evidence-based medicine [1; 2].

It is established that infectious-inflammatory pathology of the urogenital tract is the most

common cause of fertility loss in married men in Ukraine. Its share among other causes of male infertility is 34.7% [4; 7].

There is a significant increase in chronic pathology of the organs of the genitourinary system, which is caused by a combined bacterial-viral infection, such a pathology is more common in men than in women [9; 12].

The purpose of the article. To statistically evaluate the impact of chronic inflammation of the urogenital tract and other related factors on men's reproductive health, as well as predicting the likelihood of future health.

Materials and methods. The research is implemented in several consecutive stages. In the first stage, a system of key indicators of the impact on men's reproductive health, due to the transmission of chronic inflammation of the urogenital tract (CIUT), was developed by an expert survey of family doctors, dermatovenereologists, urologists. In the second stage, information on key factors of influence was collected by interviewing men during 2021-2024 by the face-to-face method [3] during the admission of patients at the clinical bases of the Department of Family Medicine and outpatient care at the NMAPE named after PL. Shupik. 422 patients participated in the survey. In the third stage, on the basis of the formed database of the interviewed patients, the correlation between the reproductive health indicator of men with CIUT and the main factors that determine it is established. In the next stage, factor variables were identified and prognostic models of the probability of fertility decline among men with CIUT were constructed [6; 8].

Research results. The system of key indicators for the impact on men's reproductive health, due to the transfer of HCTs, is proposed by the authors to be grouped into five blocks:

A. Socio-demographic characteristics;
B. History of the reproductive system;
B. Maintaining a healthy lifestyle;
D. Features of sexual life;
D. The actual parameters of semen.

The main list of potential factor variables included about 35 indicators, which could be the basis for building adequate statistical and mathematical models for assessing men's reproductive health.

Based on the defined indicator system, a survey tool (questionnaire) was developed and used in the patient survey.

Based on microdata surveys, a number of statistical models have been constructed to reflect the relationship between reproductive health indicators for men with CIUT, taking into account a number of demographic, social, medical and lifestyle factors, as well as sexuality characteristics.

The following indicators were used as indicators of men's reproductive health (dependent variables in the model):

– Proportion of reproductively healthy males (control group) – males without signs of HCT (about 29% of respondents);

– the proportion of fertile men – those who were ill with CIUT, but the disease did not affect the ability to have children (about 41%);

– the proportion of infertile men – men who have had a decrease in reproductive capacity due to the disease with CIUT (about 30% of persons).

In the course of the experimental calculations, it was found that the most appropriate approach in identifying the factors influencing the future reproductive health of men is to use linear prognostic models using structural variables.

The general appearance of the model with structural variables is given by the formula:

$$H = \beta_o + \beta_1 b_1 + \beta_2 b_2 + \ldots + \beta_n b_n ,$$

where H – is the empirical level of reproductive health of men with CIUT;

b_i – binary variables (age, existing illnesses, bad habits, etc.), $i = 1, 2, \ldots, n$;

β_0 – a free member who has the value of reproductive health of men with CIUT that corresponds to the zero values of all binary variables;

β_i – regression coefficients that reflect the influence of the factor variables included in the model (when $b_i = 1$) to the empirical level of reproductive health of men with CIUT, $i = 1, 2, \ldots, n$.

It should be noted that in predictive models with structural variables, all factor traits are binary variables, which means that they take values of 0 or 1.

The ability of a model to describe a realistic situation regarding the existence of a relationship between performance trait and factor variables is determined by the adequacy of the model. At the same time, the main characteristics of the model quality are the coefficient of determination R2, F – ratio, t – statistics [8]. The general appearance of the model with structural variables is given by the formula:

$$H = \beta_o + \beta_1 b_1 + \beta_2 b_2 + \ldots + \beta_n b_n ,$$

where H – the empirical level of reproductive health of men with CIUT;

b_i – binary variables (age, existing illnesses, bad habits, etc.), $i = 1, 2, \ldots, n$;

β_0 – a free member who has the value of reproductive health of men with CIUT that corresponds to the zero values of all binary variables;

β_i – regression coefficients that reflect the influence of the factor variables included in the model (when $b_i = 1$) to the empirical level of reproductive health of men with CIUT, $i = 1, 2, \ldots, n$.

It should be noted that in predictive models with structural variables, all factor traits are binary variables, which means that they take values of 0 or 1.

The coefficient of determination R^2 characterizes the proportion of change in the productive feature (variance of the productive feature), which is explained by the prognostic model. The higher the value R^2 , the closer the relationship between the resultant and factor traits (the relationship is measured from 0 to 1). *F* – Fisher's criterion is used to evaluate the significance of differences in variance series variances. If the values of the coefficient of determination R^2 та *F* – Fisher's criterion exceed the corresponding critical values, this is an indication of the significance of the relationship between the resultant and factor traits, and the model is adequate.

t – statistics characterize the degree of significance of individual coefficients for the factor variables included in the model and they are significant if their values exceed the standard error by more than 2 times the module.

When constructing a prognostic model of men's reproductive health, it was determined that the model was more adequate when combining the factors of each of the five indicator blocks.

The analysis of the scatter histograms and paired correlation coefficients (r), as well as a series of statistical transformations and derivatives of relative indicators, highlighted 20 indicators that could be used as factor variables to characterize the future reproductive health of men. It should also be noted that for the sake of comprehensive coverage of impact factors, factor variables were selected in such a way as to ensure that all five blocks of indicators are represented.

The following is an example of a list of selected indicators and the corresponding paired correlation coefficients to predict the likelihood of decreased reproductive ability among men with CIUT (by indicator blocks).

Indicators of Unit A "Socio-demographic characteristics":

– men 40 years and older (r = 0,423);
– body mass index above 29.5 (r = 0.118);
– Higher education (r = -0,112).

Indicators of Unit B "Medical History of the Disease":

– prostatitis recovered (r = 0.299);
– presence of STDs (r = 0,256);
– chlamydia recurrences (r = 0.246);
– herpes simplex virus (on the waist gene) (r = 0,351).

Indicators of Unit C "Maintaining a Healthy Lifestyle":

– the presence of bad habits (smoking, drinking) (r = -0,204);
– daily consumption of alcoholic beverages (r = 0,095);
– sedentary lifestyle over 8 hours a day (r = 0,180);
– no physical activity (r = 0,180).

Indicators of Unit D "Features of Sex Life":

– presence of one permanent sexual partner (r = 0,117);
– irregular intercourse (2 times a month and less) (r = 0,101);
– lack of physical pleasure from sexual intercourse (r = 0,215);
– absence of children (r = 0.118).

Indicators of Unit E "Actual Sperm Parameters":

– pathological morphotype of sperm (r = 0,401);
– leukocyte disproportion in semen (r = 0,310);
– leukocytospermia (r = 0.300);
– the presence of pathological forms of sperm (r = 0,208).

Given the limitations of the factors that can be included in the model without loss of adequacy parameters, as well as the importance of each of the selected factors, the author has assembled an expert team to discuss key indicators. According to certain blocks of indicators, the expert group identified the main criteria for the study of male reproductive health:

– Age and mass index;
– A history of STDs and prostatitis;
– Physical activity and consumption of alcoholic beverages;
– Regularity of sexual intercourse and absence of children;
– Sperm morphotype and proportion of leukocytes in sperm.

In Fig. 1 shows the indicators that negatively affect the fertility of men in the presence of HCT in anamnesis, in accordance with the degree of their impact according to the estimates of the expert group.

Thus, according to the data presented in Fig. 1. It should be noted that the greatest impact on the negative reproductive health of men with chronic heart disease has demographic characteristics of patients and sperm parameters. Thus, men older than 40 years with a pathological sperm morphotype are more likely to have a decrease in fertility in the background or after treatment with CIUT [5; 13].

As a result of identifying the most important factor variables for their further use in the prognostic models of men's reproductive health, a stepwise regression method with "joining" and "exclusion" was applied. At the same time, in order to avoid autocorrelation between the factors included in the model, the rules that in the final model should be presented indicators from different blocks are observed.

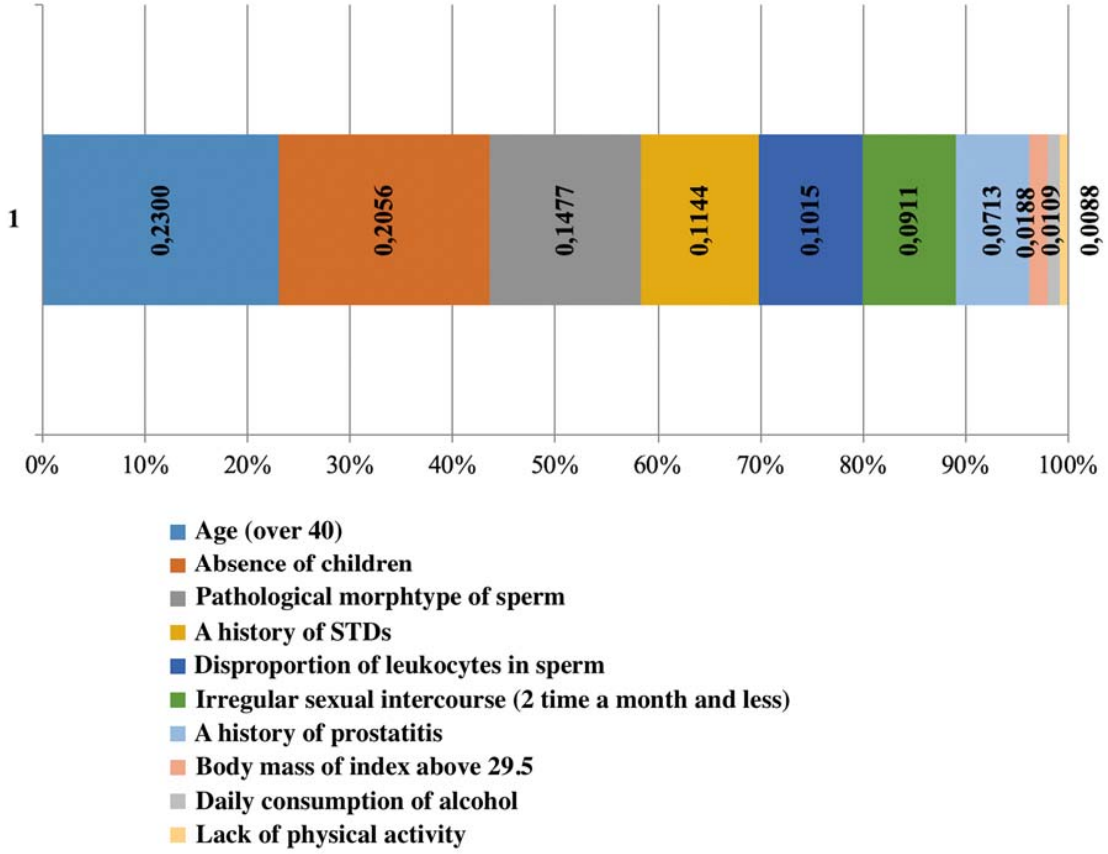

Figure 1 – Key indicators of a negative impact on male fertility in the presence of HRT in history

Source: Compiled by the authors as estimated by the expert panel

Based on the results of the analysis, it is determined that the most appropriate models are the interconnections built for the indicator "Share of infantile men" as a dependent variable.

The author proposes two equivalent models, with an acceptable level of significance of the coefficients of the model and its adequacy as a whole, but at the same time, the set of factor traits is different.

The prognostic model-1 for the likelihood of impaired reproductive ability in men with CIUT: (H_{ira}) includes the following variables:

b_1 – a man aged 40 and over (the variable assumes a value of "1" – if a man aged 40+ years; a variable takes the value of "0" – if a man is under 40 years;

b_2 – in the past, a man became ill with prostatitis ("1" – yes; "0" – no);

b_3 – the man does not exercise ("1" – yes; "0" – no).

b_4 – the man has no children ("1" – yes; "0" – no);

b_5 – leukocyte disproportion in sperm is present ("1" yes; "0" no).

The final look of the model:

$$H_{ira} = 0,178 + 0,123 \cdot b_1 + 0,206 \cdot b_2 + \\ + 0,036 \cdot b_3 + 0,100 \cdot b_4 + 0,237 \cdot b_5$$

$$\begin{pmatrix} R^2 = 0,827 & R^2_{krit} = 0,316 \\ F = 30,6 & F_{krit} = 2,8 \end{pmatrix}$$

The critical values of the given model quality characteristics correspond to the 95% probability of correlation between performance and factor variables.

Since the actual values of the coefficient of determination of R^2 and F – ratio significantly exceed their critical values, there is reason to argue that the relationship between the resultant and factor traits is adequately described by the equation obtained. The proximity of actual R^2 to one means that the association between dense traits, factor variables selected, accounts for 82.7% of the variation in the likelihood of reproductive health decline in men with CIUT.

The set of traits numbered 25 corresponds to the men with the highest likelihood of decreased reproduction: these are men 40 years of age and older (since $b_1 = 1$), who have prostatitis (since $b_2 = 1$), do not exercise (since $b_3 = 1$), have no children (since $b_4 = 1$), leukocyte indices in sperm indicate disproportion (since

$b_5 = 1$). Для цих чоловіків ймовірність зниження репродуктивності становить 88,0%.

For these men, the likelihood of a decrease in reproduction is 88.0%.

Thus, depending on the set of patient characteristics, the likelihood of decreased reproductive performance among them in the model – 1 ranges from 17.8 to 88.0%.

The prognostic model-2 for the likelihood of impaired reproductive ability in men with CIUT (H_{ira})includes the following variables:

b_1 – body mass index above 29.5 ("1" – yes; "0" – no);

b_2 – in the past, a person was ill with STD ("1" – yes; "0" – no);

b_3 – a man consumes alcoholic beverages daily ("1" – yes; "0" – no);

b_4 – irregular sexual relations (twice a month and less) ("1" – yes; "0" – no);

b_5 – morphotype of sperm pathological ("1" – yes; "0" – no).

The final look of the model:

$$H_{ira} = 0{,}187 + 0{,}103 \cdot b_1 + 0{,}215 \cdot b_2 + \\ + 0{,}058 \cdot b_3 + 0{,}071 \cdot b_4 + 0{,}287 \cdot b_5$$

$$\begin{pmatrix} R^2 = 0{,}687 & R^2_{crit} = 0{,}306 \\ F = 28{,}2 & F_{crit} = 2{,}8 \end{pmatrix}$$

The proposed model is adequate to the actual values of the model's quality characteristics for 95% probability. The association between the likelihood of impaired reproductive ability among men with CIUT and factor variables is dense and explains 68.7% of the variation in the outcome variable. Another 31.3% of the variation is due to factors not included in the model.

The 24 feature set corresponds to men with the highest likelihood of decreased reproductive performance: these are men with a body mass index above 29.5 (since $b_1 = 1$), who have had STDs in the past (since $b_2 = 1$), who drink alcohol daily (since $b_3 = 1$), have irregular (2 times a month and less) sexual relations (since $b_4 = 1$), with pathological morph type of sperm (since $b_5 = 1$). For these men, the likelihood of a decrease in reproduction is 92.8%.

Thus, depending on the set of patient characteristics, the likelihood of reproductive decline among them in the model – 2 ranges from 18.7% to 92.8%.

For convenience of using the results of modeling and unifying approaches to the treatment of patients, a scale for assessing the likelihood of reproductive health decline in men with chronic heart failure has been proposed. The scale provides for the following classification of patients:

– 0,0 – 0,30 (or 0,0 – 30,0%) – low probability of reproductive health disorders;

– 0.31 – 0.60 (or 31.0 – 60.0%) – the average probability of reproductive health disorders;

– 0.61 – 0.93 (or 61.0 – 93.0%) – high probability of reproductive health disorders.

The results of the testing of the scale of assessment based on patient data gave the distribution shown in Fig. 2.

The data presented in Fig. 2. Evidence of sufficiently close patient distributions on the scale of the likelihood of male reproductive health disorders in both variants of the prognostic models (the relationship between the distributions is 0.874). This indicates that, if the necessary information is available, the proposed models can be equally used in the planning of treatment regimens for men with CIUT.

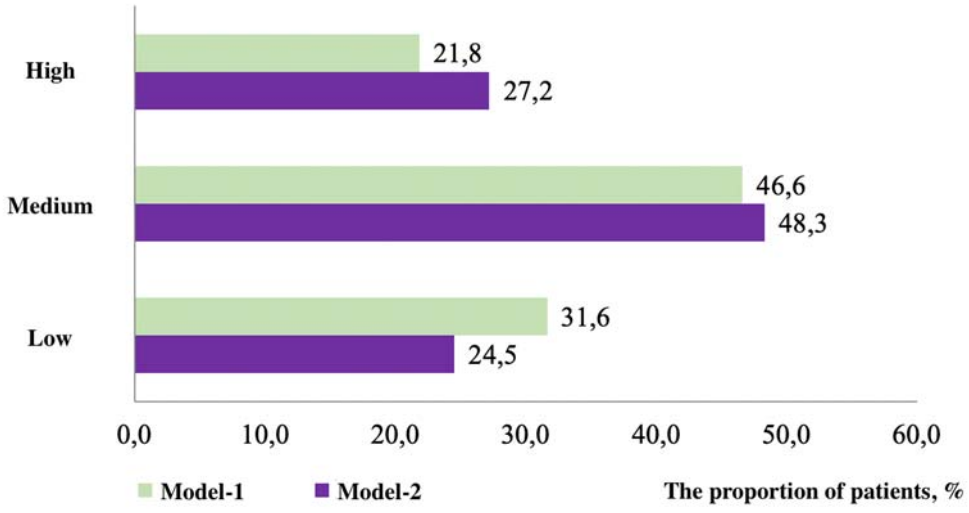

Figure 2 – Distribution of patients by likelihood of reproductive health disorders in the presence of CIUT according to the rating scale

However, it should be borne in mind that Model 1, like Model 2, do not cover the whole set of factors that determine the reproductive health of men with HCT. Recall that model – 1 describes 82.7% of the variation in the resultant variable, while model – 2 describes only 68.2%. Therefore, the impact of a number of factors is beyond the model. According to the author, among other factors significant influence are other, not included in the model, semen parameters, which should be taken into account comprehensively in determining the treatment regimen of patients. This involves considering both the sperm morphotype and the leukocyte fraction in the sperm.

Conclusions. 1. Medical, social characteristics and spermatological data should be included to evaluate the reproductive health of men with a view to comprehensively assessing the reproductive health of men with CIUT.

2. In the practice of the family doctor, it is advisable to use prognostic models of reproductive health disorders for men with CIUT not only for diagnostic but also for therapeutic and prophylactic purposes.

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РЕПРОДУКТИВНЕ ЗДОРОВ'Я ЧОЛОВІКІВ ІЗ ХРОНІЧНИМ ЗАПАЛЕННЯМ СЕЧОСТАТЕВИХ ШЛЯХІВ

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Анотація. В статті здійснено спробу статистично оцінити вплив хронічного запалення урогенітального тракту, а також інших супутніх факторів на репродуктивне здоров'я чоловіків, а також прогнозування ймовірності бути здоровим в майбутньому. Система ключових індикаторів впливу на репродуктивне здоров'я чоловіків, внаслідок перенесення хронічного запалення урогенітального тракту (ХЗУТ) згруповано у п'ять блоків: соціально-демографічні характеристики;

хвороби статевої системи в анамнезі; дотримання здорового способу життя; особливості статевого життя; фактичні параметри сперми. Найбільший вплив на негативне репродуктивне здоров'я чоловіків, які хворіли на ХЗУТ мають демографічні характеристики пацієнтів та параметри сперми. Так, чоловіки старше 40 років з паталогічним морфотипом сперматозоїдів з високою ймовірністю матимуть зниження фертильності на фоні або після лікування ХЗУТ. В ході експериментальних розрахунків встановлено, що найбільш прийнятним підходом у виявленні чинників впливу на майбутнє репродуктивне здоров'я чоловіків є застосування лінійних прогностичних моделей з використанням структурних змінних. При побудові прогностичної моделі стану репродуктивного здоров'я чоловіків визначено, що модель є більш адекватною при поєднанні факторів кожного з п'яти блоків індикаторів. За результатами виявлення найбільш вагомих факторних змінних для їх подальшого використання в прогностичних моделях стану репродуктивного здоров'я чоловіків застосовано метод покрокової регресії з "приєднанням" та "виключенням". Запропоновані дві рівнозначні моделі для розрахунку ймовірності зниження репродуктивної здатності серед чоловіків з ХЗУТ з прийнятним рівнем значущості коефіцієнтів моделі та її адекватності в цілому, водночас, проте набір факторних ознак у них є різним. Для зручності користування результатами моделювання та уніфікації підходів до лікування пацієнтів, запропонована шкала оцінювання ймовірності зниження репродуктивного здоров'я чоловіків з ХЗУТ.

Ключові слова: репродуктивне здоров'я, хронічне запалення урогенітального тракту чоловіків, математичне моделювання.

Стаття надійшла до редакції 16.09.2024