



INTEGRATED DIAGNOSTIC AND PROGNOSTIC SCORING SCALES FOR CERVICAL CANCER RISK ASSESSMENT

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Abstract:

Cervical cancer remains one of the most common oncological diseases in women and poses a serious medical and social issue in many countries worldwide, including Uzbekistan. Despite advancements in screening and prevention programs, the success of early detection largely relies on the prompt assessment of individual risk factors and the application of objective diagnostic tools. The purpose of this study is to develop an integrated diagnostic and prognostic scoring scale for cervical cancer risk assessment and to create software for automating the calculation of the combined risk index. A scoring scale model based on a multifactorial approach, including clinical, behavioral, and epidemiological indicators, is proposed. Each factor is assigned a specific weight coefficient reflecting its contribution to the total risk. Using this model, an algorithm has been developed to calculate the integrated risk index, enabling stratification of patients into low, moderate, and high-risk groups.

For practical use of the developed model, a software package was created to enable input of patient data, automatically calculate the risk score, and visualize the results. The system's modular architecture includes sections for data entry, risk calculation, result analysis, and parameter settings. Using the software improves the accuracy of risk assessment, speeds up processing of medical information, and supports clinical decision-making.

The results suggest that using integrated scoring scales is promising for early diagnosis and prevention of cervical cancer. The developed method can be applied in clinical settings and preventive screening programs to identify high-risk groups and improve the effectiveness of preventive efforts.

Keywords: cervical cancer, risk factors, diagnostic scale, prognostic model, mathematical modeling, screening.

INTRODUCTION

Cervical cancer is one of the most common forms of oncological diseases in women and presents a serious medical and social problem [1, 9]. According to international epidemiological studies, hundreds of thousands of new cases are registered annually, a significant portion of which are detected at advanced stages [1, 2].

The main etiological factor in the development of cervical cancer is persistent infection with high-risk human papillomavirus (HPV). However, the progression to malignancy is determined by a complex interaction of viral, immunological, behavioural, and hormonal factors [8]. In modern clinical practice, various screening methods are used, including cytological examination (Pap test), HPV testing, and colposcopy [6,7]. Despite their high informativeness, these methods do not fully

account for the array of risk factors and cannot predict the likelihood of disease development in a specific patient [4,7]. Consequently, there is increasing interest in developing integrated diagnostic and prognostic scales that allow for a quantitative assessment of an individual's risk of developing cervical cancer [4,5]. The use of such scales can improve the effectiveness of screening programmes and optimise clinical monitoring strategies [3,6].

THE STUDY AIMS to develop an integrated diagnostic and prognostic scoring scale for assessing the risk of cervical cancer based on a set of clinical and epidemiological factors.



MATERIALS AND METHODS

The study involved analysing risk factors most frequently associated with the development of cervical cancer, based on clinical and epidemiological research data [2, 8]. A scoring system was developed to assess the quantitative influence of each factor.

Each risk factor was assigned a weighting coefficient reflecting the degree of its impact on the likelihood of disease development. The integrated risk indicator was calculated as the sum of scores across all analysed parameters.

The integrated risk was determined using the formula:

$$R = \sum_{i=1}^n w_i x_i$$

- where
- R - the overall risk index,
- w_i - the weight coefficient of the risk factor,

x_i - the presence or degree of expression of the factor.

Main risk factors

The key factors included in the model are:

- presence of high-risk human papillomavirus infection [8];
- patient's age;
- early initiation of sexual activity;
- number of sexual partners;
- smoking;
- prolonged use of hormonal contraceptives;
- immunodeficiency conditions;
- presence of cervical intraepithelial neoplasia (CIN) [6].

Integral risk scale (Cervical Cancer Risk Score - CCRS)

The proposed scale is an integral point-based system for assessing risk factors.

Table 1. Scoring system for risk factors

Factor	Criterion	Score
High-risk HPV	Positive test	6
Age	>35 years	2
Early Sexual Debut	<18 years	2
Number of Partners	>3	3
Smoking	Regular	2
Hormonal Contraceptives	>5 years	2
Immunodeficiency	Present	3
CIN II-III	Detected	5

Interpretation of the integral risk index

The integral CCRS indicator is calculated as the sum of the scores.

Баллы	Уровень риска
0–4	Low
5–8	Moderate
9–13	High
13 и выше	Very high

Prognostic model

A logistic model can be used to predict the probability of malignant process development:

$$P = \frac{1}{1 + e^{-(\beta_0 + \beta_1 R)}}$$

where

- P - the probability of developing cervical cancer,
- R - integral index CCRS.

To automate the calculation of the integral diagnostic and prognostic risk index for cervical cancer, a software system was developed that implements algorithms of a mathematical model for scoring risk factors [4]. The software is designed for use in both clinical practice and

scientific research related to analyzing risk factors for oncological diseases of the female reproductive system. The main window of the software is a title form containing the primary control and navigation elements. At the center of the interface is a graphical image of the female reproductive system's anatomical structure, which visually highlights the software product's medical focus. At the bottom of the main window are four primary functional buttons that provide access to key modules of the system (see Fig. 1):

- data entry module;
- mathematical calculation module;
- results visualization module;
- program parameter configuration module.



Fig. 1. Interface of the title form of the software complex for the comprehensive assessment of cervical cancer risk

The 'Patient Questionnaire' module (Fig. 2) is designed for entering initial medical and personal information necessary for further calculation of the integrated risk index. In this form, the user enters the patient's main identification and clinical data. At the top of the form, **the patient's full name** is entered, followed by basic physiological parameters, including age, body weight (kg), and height (cm). The program uses these indicators to calculate the body mass index. There is also a field for indicating the duration of pregnancy (in weeks), which allows for consideration of the physiological features of the patient's condition during risk analysis. Below are text fields for entering hereditary diseases, medical history, and harmful habits, which may serve as additional risk factors. At the bottom of the form, there are control buttons: • 'Save' – records the entered data and transmits it for subsequent analysis; • 'Clear' - deletes the entered information and allows the questionnaire to be filled out again. The entered data are stored in the database and used for further analysis [3].

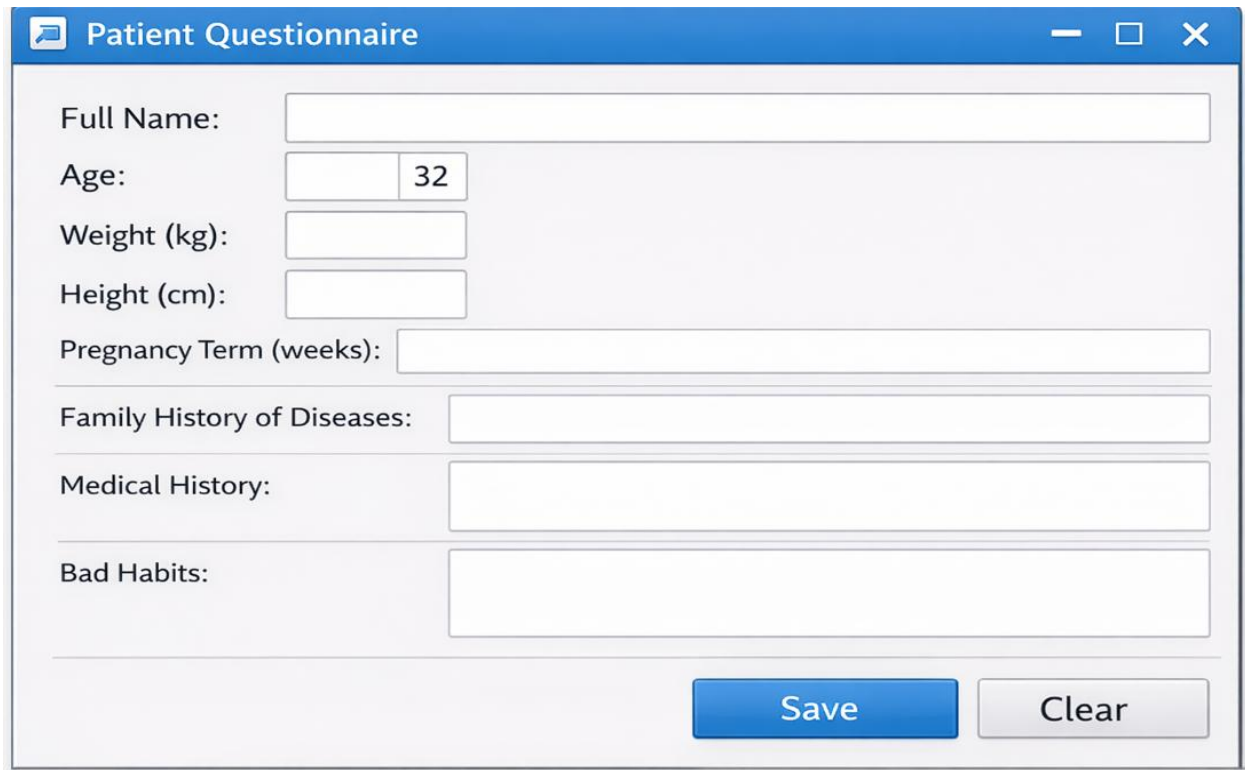


Fig. 2. 'Patient Questionnaire' Module

The Risk Calculation Module (Fig. 3) implements an algorithm to compute the integral risk indicator using the developed mathematical model. The central element of the form is the 'Calculate' button, which, when pressed, initiates the information processing algorithm. During the calculations, the programme performs:

- conversion of input data into numerical indicators;
- assignment of weight

- coefficients to each risk factor;
- summing of scores;
- determination of the final integral risk index. After the calculations are completed, an intermediate risk index is displayed on the screen, which is a numerical value (for example, 0.45) that characterises the probability of developing a pathological condition. The calculation results are used to interpret the patient's condition.



Fig. 3. Risk calculation module

The 'Results' module is designed for the visualisation and interpretation of the calculated data. In the central part of the form, there is a graphical

risk level indicator, made in the form of a colour scale with three zones:

- green zone - low risk,

- yellow zone - medium risk,
- red zone - high risk.

The scale displays the numerical value of the integrated risk index, which is automatically positioned at the corresponding level. On the right side of the form, there is an 'Indicators' block where key medical parameters of the patient are displayed, including:

- body mass index (BMI);

- blood pressure;
- blood glucose level.

At the bottom of the form, the system's final conclusion is shown — for example, the risk category 'Medium risk'. This presentation of information facilitates the doctor's interpretation of the results and decision-making.

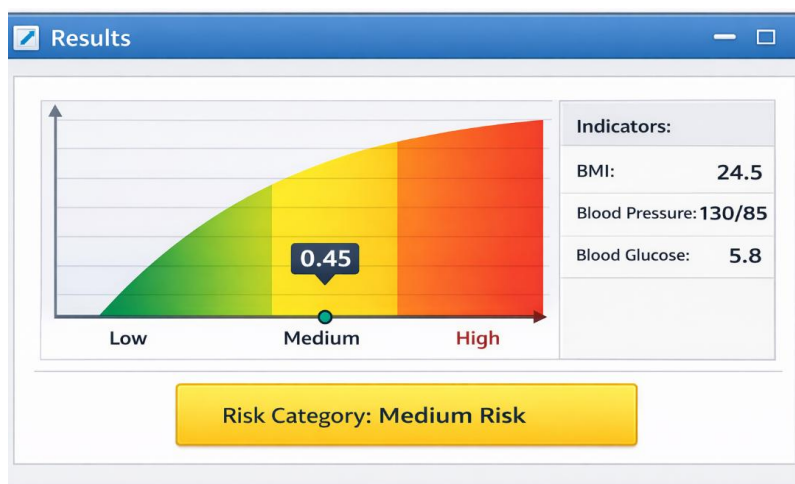


Рис.4. Модуль «Результаты»

- **The 'Settings' module (Fig. 5)** is designed for configuring the programme parameters and selecting the factors to be considered when calculating the overall risk index.
- At the top of the form are switches that allow turning on or off the consideration of individual parameters:
 - **Body Mass Index (BMI) consideration,**
 - **Blood pressure consideration,**
 - **Glucose level consideration.**
- Below is the threshold values section, where the user can set critical levels for each indicator:
 - **BMI value,**
 - **Limit values for blood pressure,**
 - **Acceptable blood glucose level.**
- At the bottom of the form are control buttons:
 - **'Save'** – applies the selected parameters;
 - **'Cancel'** - reverts to previous settings without saving changes.

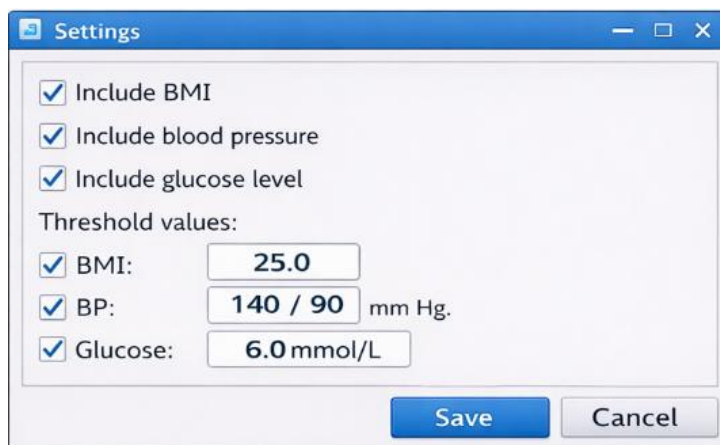


Fig. 5. System configuration module

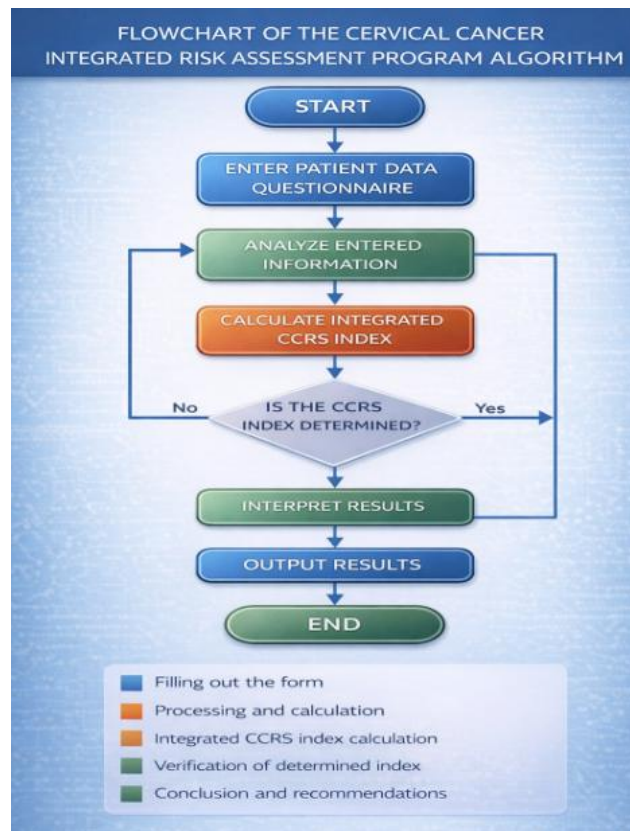


Fig. 6. Block diagram of the software complex's operation algorithm

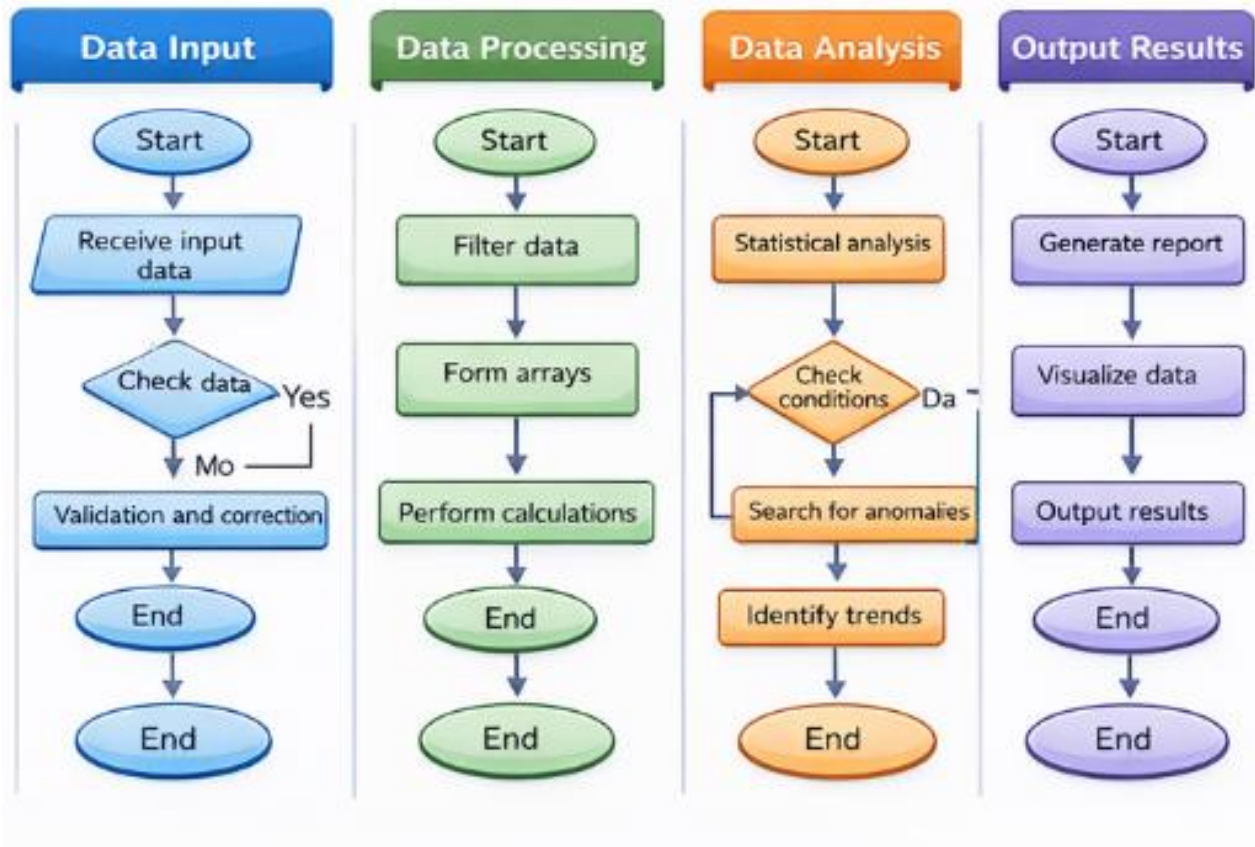


Fig. 7. Block diagrams of the program modules' operation



In modern clinical practice, various approaches are used to assess the risk of developing cervical cancer. Most of them are based on analyses of individual diagnostic indicators, such as cytological examination results, human papillomavirus testing, or histological assessment of precancerous changes. However, such

methods do not always allow for the consideration of a comprehensive set of risk factors [4, 7]. The most common risk assessment models include cytological classification, systems for evaluating the severity of cervical intraepithelial neoplasia, and screening algorithms based on HPV testing [6, 7].

Table 2. Comparison of existing diagnostic scales and the integral scale CCRS

Criterion	Cytological Assessment	HPV Screening	CIN Assessment	CCRS Scale
Main Principle	Morphological cell changes	Presence of virus	Degree of neoplasia	Integrated risk
Consideration of behavioral factors	No	No	No	Yes
Consideration of epidemiological factors	Net	No	Net	Da
Quantitative risk assessment	Ograninenna	Limited	Hactinho	Yes
Quantitative risk assessment	Limited	Limited	Partial	Full
Ability to predict	Low	Medium	Medium	High
Application in digital systems	Limited	Yes	Yes	Yes
Possibility of risk stratification	Limited	Medium	Medium	Medium
Possability of risk	Limited	Medium	Medium	High

A key feature of existing scales is their focus on diagnosing already established morphological changes, whereas an overall assessment of individual disease risk is used much less frequently [4, 5, 10]. The comparison shows that traditional diagnostic methods primarily aim to detect existing pathological changes in the cervical epithelium. At the same time, the assessment of individual risk of developing the disease at early stages remains limited [7]. The proposed CCRS scale differs in that it combines several groups of factors:

- clinical,
- epidemiological,
- behavioural,
- biological.

This integrated approach enables more accurate stratification of patients by risk level and the use of the resulting data for disease prognosis [4, 5, 10]. An additional advantage of the model is its integration into digital medicine systems and

automated clinical decision support systems [4].

The main advantages of the model are as follows:

- comprehensive risk factor assessment;
- quantitative interpretation of results;
- potential for disease development prediction;
- ease of use in clinical practice;
- applicability in screening programmes [3, 4, 5].

DISCUSSION

The conducted study demonstrates that the use of integrated diagnostic and prognostic scales can significantly enhance the effectiveness of assessing individual risk of developing cervical cancer. Unlike traditional diagnostic methods, which primarily focus on identifying already established morphological changes, integrated risk models enable early stratification of patients based on a combination of clinical, epidemiological, and behavioural factors [4, 5, 10].

It should be noted that in modern clinical practice, the main screening tools for cervical cancer



remain cytological examination (Pap test), human papillomavirus (HPV) testing, and colposcopy [6, 7]. Despite their high diagnostic significance, these methods are primarily used to detect precancerous changes and early stages of the disease. At the same time, the possibilities for predicting the individual risk of developing pathology remain limited [4, 7]. Therefore, the development of integrated scoring systems for risk assessment is becoming particularly relevant, as such models allow for the consideration of a comprehensive set of factors that influence the likelihood of disease occurrence [5].

The integral risk scale proposed in this study differs in that it adopts a multifactorial approach to assessing the likelihood of disease development. The model includes demographic indicators, health status parameters, anamnesis data, and modifiable lifestyle factors. The use of weighting coefficients for each parameter enables a quantitative assessment of the contribution of individual factors to overall risk formation and the creation of a single integrated index. Such an approach aligns with modern principles of personalised medicine, where disease prevention and diagnosis are based on the patient's individual characteristics.

An important advantage of the developed model is its software implementation. The created software complex ensures automated data collection, information processing, and calculation of the integral risk index [4]. Using this software tool minimises the likelihood of errors associated with manual calculations and significantly speeds up the process of analysing medical data. Additionally, the modular architecture of the software complex provides system flexibility and the potential for further expansion, including the addition of new risk factors or integration with electronic medical information systems.

An important element of the developed software complex is the system for visualising the results. Presenting the risk level as a colour scale with highlighted zones of low, medium, and high risk facilitates the interpretation of the obtained data. It enhances the programme's usability for medical professionals. This form of visualisation contributes to quicker clinical decision-making and can be particularly useful during preventive examinations and mass screening programmes [4].

The developed model is particularly significant in the context of the development of national healthcare systems, where improving the efficiency of early detection of oncological diseases is a priority task [3, 9]. Specifically, for Uzbekistan's healthcare system, the implementation of digital risk assessment tools can help improve the effectiveness of screening programmes, optimise the allocation of medical resources, and enable the timely identification of high-risk groups among

women. The use of integrated risk models not only enables the identification of patients requiring more detailed examination but also helps develop personalised preventive strategies [4,5].

Furthermore, the proposed approach opens up prospects for further development of digital technologies in medicine, including the integration of the developed scale with artificial intelligence systems, medical databases, and electronic health platforms. In the future, this could lead to the development of intelligent decision support systems capable of analysing large volumes of medical data and predicting disease risk with high accuracy [4,10].

Thus, the proposed integrated diagnostic and prognostic scale, as well as the developed software complex, represent a promising tool for assessing the risk of cervical cancer. The use of this approach may contribute to improving early diagnosis systems, enhancing the effectiveness of preventive measures, and advancing digital technologies in modern medicine [3, 4].

CONCLUSION

During the conducted study, an integral diagnostic and prognostic scoring scale for assessing the risk of developing cervical cancer was developed, based on a comprehensive analysis of clinical, epidemiological, and behavioural factors [4, 5]. The proposed model enables a quantitative assessment of an individual's risk of developing the disease and stratifies patients according to the likelihood of pathological processes occurring.

The developed scale is characterised by a multifactorial approach and the use of weighting coefficients that reflect each risk factor's contribution to the formation of the integral indicator. Such an approach provides a more objective risk assessment compared to methods based on the analysis of individual diagnostic indicators.

An important result of the study is the software implementation of the proposed model. The software complex automates data collection, the calculation of the integral risk index, and the visualisation of the results [4]. The system's modular architecture, which includes data entry, risk calculation, result display, and parameter setting modules, ensures ease of use and supports further development.

The use of graphical visualisation of results and a colour scale of risk levels allows for simplified interpretation of the obtained data and enhances the effectiveness of clinical decision-making. This makes the developed software system a promising tool for clinical practice and preventive screening programmes [4, 6].

The practical significance of the work lies in the possibility of applying the proposed scale for the early detection of high-risk groups for the development of cervical cancer. In the context of improving the



healthcare system and the development of digital technologies in medicine, the implementation of such software solutions can contribute to increasing the efficiency of preventive measures and optimising the diagnostic process [3, 4, 9].

A promising direction for further research is the expansion of the clinical database, conducting multicentre validation of the developed model, and integrating the software complex with medical information systems. This will help improve the accuracy of prognostic assessment and facilitate wider implementation of the developed technology into healthcare practice.

Thus, the developed integrated scoring scale and the software complex based on it represent an effective tool for assessing the risk of cervical cancer, contributing to the improvement of early diagnostic methods and the development of digital technologies in modern medicine [4, 5].

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