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ЕЖЕМЕСЯЧНЫЙ НАУЧНЫЙ ЖУРНАЛ

Медицинские новости Грузии

საქართველოს სამედიცინო სიახლენი

GEORGIAN MEDICAL NEWS

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GMN: Georgian Medical News is peer-reviewed, published monthly journal committed to promoting the science and art of medicine and the betterment of public health, published by the GMN Editorial Board since 1994. GMN carries original scientific articles on medicine, biology and pharmacy, which are of experimental, theoretical and practical character; publishes original research, reviews, commentaries, editorials, essays, medical news, and correspondence in English and Russian.

GMN is indexed in MEDLINE, SCOPUS, PubMed and VINITI Russian Academy of Sciences. The full text content is available through EBSCO databases.

GMN: Медицинские новости Грузии - ежемесячный рецензируемый научный журнал, издаётся Редакционной коллегией с 1994 года на русском и английском языках в целях поддержки медицинской науки и улучшения здравоохранения. В журнале публикуются оригинальные научные статьи в области медицины, биологии и фармации, статьи обзорного характера, научные сообщения, новости медицины и здравоохранения. Журнал индексируется в MEDLINE, отражён в базе данных SCOPUS, PubMed и ВИНИТИ РАН. Полнотекстовые статьи журнала доступны через БД EBSCO.

GMN: Georgian Medical News – საქართველოს სამედიცინო სიახლენი – არის ყოველთვიური სამეცნიერო სამედიცინო რეცენზირებადი ჟურნალი, გამოიცემა 1994 წლიდან, წარმოადგენს სარედაქციო კოლეგიისა და აშშ-ის მეცნიერების, განათლების, ინდუსტრიის, ხელოვნებისა და ბუნებისმეტყველების საერთაშორისო აკადემიის ერთობლივ გამოცემას. GMN-ში რუსულ და ინგლისურ ენებზე ქვეყნდება ექსპერიმენტული, თეორიული და პრაქტიკული ხასიათის ორიგინალური სამეცნიერო სტატიები მედიცინის, ბიოლოგიისა და ფარმაციის სფეროში, მიმოხილვითი ხასიათის სტატიები.

ჟურნალი ინდექსირებულია MEDLINE-ის საერთაშორისო სისტემაში, ასახულია SCOPUS-ის, PubMed-ის და ВИНИТИ РАН-ის მონაცემთა ბაზებში. სტატიების სრული ტექსტი ხელმისაწვდომია EBSCO-ს მონაცემთა ბაზებიდან.

WEBSITE

www.geomednews.com

К СВЕДЕНИЮ АВТОРОВ!

При направлении статьи в редакцию необходимо соблюдать следующие правила:

1. Статья должна быть представлена в двух экземплярах, на русском или английском языках, напечатанная через **полтора интервала на одной стороне стандартного листа с шириной левого поля в три сантиметра**. Используемый компьютерный шрифт для текста на русском и английском языках - **Times New Roman** (**Кириллица**), для текста на грузинском языке следует использовать **AcadNusx.** Размер шрифта - **12**. К рукописи, напечатанной на компьютере, должен быть приложен CD со статьей.

2. Размер статьи должен быть не менее десяти и не более двадцати страниц машинописи, включая указатель литературы и резюме на английском, русском и грузинском языках.

3. В статье должны быть освещены актуальность данного материала, методы и результаты исследования и их обсуждение.

При представлении в печать научных экспериментальных работ авторы должны указывать вид и количество экспериментальных животных, применявшиеся методы обезболивания и усыпления (в ходе острых опытов).

4. К статье должны быть приложены краткое (на полстраницы) резюме на английском, русском и грузинском языках (включающее следующие разделы: цель исследования, материал и методы, результаты и заключение) и список ключевых слов (key words).

5. Таблицы необходимо представлять в печатной форме. Фотокопии не принимаются. **Все цифровые, итоговые и процентные данные в таблицах должны соответствовать таковым в тексте статьи**. Таблицы и графики должны быть озаглавлены.

6. Фотографии должны быть контрастными, фотокопии с рентгенограмм - в позитивном изображении. Рисунки, чертежи и диаграммы следует озаглавить, пронумеровать и вставить в соответствующее место текста **в tiff формате**.

В подписях к микрофотографиям следует указывать степень увеличения через окуляр или объектив и метод окраски или импрегнации срезов.

7. Фамилии отечественных авторов приводятся в оригинальной транскрипции.

8. При оформлении и направлении статей в журнал МНГ просим авторов соблюдать правила, изложенные в «Единых требованиях к рукописям, представляемым в биомедицинские журналы», принятых Международным комитетом редакторов медицинских журналов - http://www.spinesurgery.ru/files/publish.pdf и http://www.nlm.nih.gov/bsd/uniform_requirements.html
В конце каждой оригинальной статьи приводится библиографический список. В список литературы включаются все материалы, на которые имеются ссылки в тексте. Список составляется в алфавитном порядке и нумеруется. Литературный источник приводится на языке оригинала. В списке литературы сначала приводятся работы, написанные знаками грузинского алфавита, затем кириллицей и латиницей. Ссылки на цитируемые работы в тексте статьи даются в квадратных скобках в виде номера, соответствующего номеру данной работы в списке литературы. Большинство цитированных источников должны быть за последние 5-7 лет.

9. Для получения права на публикацию статья должна иметь от руководителя работы или учреждения визу и сопроводительное отношение, написанные или напечатанные на бланке и заверенные подписью и печатью.

10. В конце статьи должны быть подписи всех авторов, полностью приведены их фамилии, имена и отчества, указаны служебный и домашний номера телефонов и адреса или иные координаты. Количество авторов (соавторов) не должно превышать пяти человек.

11. Редакция оставляет за собой право сокращать и исправлять статьи. Корректура авторам не высылается, вся работа и сверка проводится по авторскому оригиналу.

12. Недопустимо направление в редакцию работ, представленных к печати в иных издательствах или опубликованных в других изданиях.

При нарушении указанных правил статьи не рассматриваются.

REQUIREMENTS

Please note, materials submitted to the Editorial Office Staff are supposed to meet the following requirements:

1. Articles must be provided with a double copy, in English or Russian languages and typed or compu-ter-printed on a single side of standard typing paper, with the left margin of **3** centimeters width, and **1.5** spacing between the lines, typeface - **Times New Roman** (**Cyrillic**), print size - **12** (referring to Georgian and Russian materials). With computer-printed texts please enclose a CD carrying the same file titled with Latin symbols.

2. Size of the article, including index and resume in English, Russian and Georgian languages must be at least 10 pages and not exceed the limit of 20 pages of typed or computer-printed text.

3. Submitted material must include a coverage of a topical subject, research methods, results, and review.

Authors of the scientific-research works must indicate the number of experimental biological species drawn in, list the employed methods of anesthetization and soporific means used during acute tests.

4. Articles must have a short (half page) abstract in English, Russian and Georgian (including the following sections: aim of study, material and methods, results and conclusions) and a list of key words.

5. Tables must be presented in an original typed or computer-printed form, instead of a photocopied version. **Numbers, totals, percentile data on the tables must coincide with those in the texts of the articles.** Tables and graphs must be headed.

6. Photographs are required to be contrasted and must be submitted with doubles. Please number each photograph with a pencil on its back, indicate author's name, title of the article (short version), and mark out its top and bottom parts. Drawings must be accurate, drafts and diagrams drawn in Indian ink (or black ink). Photocopies of the X-ray photographs must be presented in a positive image in **tiff format**.

Accurately numbered subtitles for each illustration must be listed on a separate sheet of paper. In the subtitles for the microphotographs please indicate the ocular and objective lens magnification power, method of coloring or impregnation of the microscopic sections (preparations).

7. Please indicate last names, first and middle initials of the native authors, present names and initials of the foreign authors in the transcription of the original language, enclose in parenthesis corresponding number under which the author is listed in the reference materials.

8. Please follow guidance offered to authors by The International Committee of Medical Journal Editors guidance in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication available online at: http://www.nlm.nih.gov/bsd/uniform_requirements.html
http://www.icmje.org/urm_full.pdf
In GMN style for each work cited in the text, a bibliographic reference is given, and this is located at the end of the article under the title "References". All references cited in the text must be listed. The list of references should be arranged alphabetically and then numbered. References are numbered in the text [numbers in square brackets] and in the reference list and numbers are repeated throughout the text as needed. The bibliographic description is given in the language of publication (citations in Georgian script are followed by Cyrillic and Latin).

9. To obtain the rights of publication articles must be accompanied by a visa from the project instructor or the establishment, where the work has been performed, and a reference letter, both written or typed on a special signed form, certified by a stamp or a seal.

10. Articles must be signed by all of the authors at the end, and they must be provided with a list of full names, office and home phone numbers and addresses or other non-office locations where the authors could be reached. The number of the authors (co-authors) must not exceed the limit of 5 people.

11. Editorial Staff reserves the rights to cut down in size and correct the articles. Proof-sheets are not sent out to the authors. The entire editorial and collation work is performed according to the author's original text.

12. Sending in the works that have already been assigned to the press by other Editorial Staffs or have been printed by other publishers is not permissible.

Articles that Fail to Meet the Aforementioned Requirements are not Assigned to be Reviewed.

ავტორთა საყურადღებოდ!

რედაქციაში სტატიის წარმოდგენისას საჭიროა დავიცვათ შემდეგი წესები:

1. სტატია უნდა წარმოადგინოთ 2 ცალად, რუსულ ან ინგლისურ ენებზე,დაბეჭდილი სტანდარტული ფურცლის 1 გვერდზე, 3 სმ სიგანის მარცხენა ველისა და სტრიქონებს შორის 1,5 ინტერვალის დაცვით. გამოყენებული კომპიუტერული შრიფტი რუსულ და ინგლისურენოვან ტექსტებში - **Times New Roman (Кириллица)**, ხოლო ქართულენოვან ტექსტში საჭიროა გამოვიყენოთ **AcadNusx.** შრიფტის ზომა – 12. სტატიას თან უნდა ახლდეს CD სტატიით.

2. სტატიის მოცულობა არ უნდა შეადგენდეს 10 გვერდზე ნაკლებს და 20 გვერდზე მეტს ლიტერატურის სიის და რეზიუმეების (ინგლისურ, რუსულ და ქართულ ენებზე) ჩათვლით.

3. სტატიაში საჭიროა გაშუქდეს: საკითხის აქტუალობა; კვლევის მიზანი; საკვლევი მასალა და გამოყენებული მეთოდები; მიღებული შედეგები და მათი განსჯა. ექსპერიმენტული ხასიათის სტატიების წარმოდგენისას ავტორებმა უნდა მიუთითონ საექსპერიმენტო ცხოველების სახეობა და რაოდენობა; გაუტკივარებისა და დაძინების მეთოდები (მწვავე ცდების პირობებში).

4. სტატიას თან უნდა ახლდეს რეზიუმე ინგლისურ, რუსულ და ქართულ ენებზე არანაკლებ ნახევარი გვერდის მოცულობისა (სათაურის, ავტორების, დაწესებულების მითითებით და უნდა შეიცავდეს შემდეგ განყოფილებებს: მიზანი, მასალა და მეთოდები, შედეგები და დასკვნები; ტექსტუალური ნაწილი არ უნდა იყოს 15 სტრიქონზე ნაკლები) და საკვანძო სიტყვების ჩამონათვალი (key words).

5. ცხრილები საჭიროა წარმოადგინოთ ნაბეჭდი სახით. ყველა ციფრული, შემაჯამებელი და პროცენტული მონაცემები უნდა შეესაბამებოდეს ტექსტში მოყვანილს.

6. ფოტოსურათები უნდა იყოს კონტრასტული; სურათები, ნახაზები, დიაგრამები - დასათაურებული, დანომრილი და სათანადო ადგილას ჩასმული. რენტგენოგრამების ფოტოასლები წარმოადგინეთ პოზიტიური გამოსახულებით **tiff** ფორმატში. მიკროფოტოსურათების წარწერებში საჭიროა მიუთითოთ ოკულარის ან ობიექტივის საშუალებით გადიდების ხარისხი, ანათალების შეღებვის ან იმპრეგნაციის მეთოდი და აღნიშნოთ სურათის ზედა და ქვედა ნაწილები.

7. სამამულო ავტორების გვარები სტატიაში აღინიშნება ინიციალების თანდართვით, უცხოურისა – უცხოური ტრანსკრიპციით.

8. სტატიას თან უნდა ახლდეს ავტორის მიერ გამოყენებული სამამულო და უცხოური შრომების ბიბლიოგრაფიული სია (ბოლო 5-8 წლის სიღრმით). ანბანური წყობით წარმოდგენილ ბიბლიოგრაფიულ სიაში მიუთითეთ ჯერ სამამულო, შემდეგ უცხოელი ავტორები (გვარი, ინიციალები, სტატიის სათაური, ჟურნალის დასახელება, გამოცემის ადგილი, წელი, ჟურნალის №, პირველი და ბოლო გვერდები). მონოგრაფიის შემთხვევაში მიუთითეთ გამოცემის წელი, ადგილი და გვერდების საერთო რაოდენობა. ტექსტში კვადრატულ ფჩხილებში უნდა მიუთითოთ ავტორის შესაბამისი N ლიტერატურის სიის მიხედვით. მიზანშეწონილია, რომ ციტირებული წყაროების უმეტესი ნაწილი იყოს 5-6 წლის სიღრმის.

9. სტატიას თან უნდა ახლდეს: ა) დაწესებულების ან სამეცნიერო ხელმძღვანელის წარდგინება, დამოწმებული ხელმოწერითა და ბეჭდით; ბ) დარგის სპეციალისტის დამოწმებული რეცენზია, რომელშიც მითითებული იქნება საკითხის აქტუალობა, მასალის საკმაობა, მეთოდის სანდოობა, შედეგების სამეცნიერო-პრაქტიკული მნიშვნელობა.

10. სტატიის ბოლოს საჭიროა ყველა ავტორის ხელმოწერა, რომელთა რაოდენობა არ უნდა აღემატებოდეს 5-ს.

11. რედაქცია იტოვებს უფლებას შეასწოროს სტატია. ტექსტზე მუშაობა და შეჯერება ხდება საავტორო ორიგინალის მიხედვით.

12. დაუშვებელია რედაქციაში ისეთი სტატიის წარდგენა, რომელიც დასაბეჭდად წარდგენილი იყო სხვა რედაქციაში ან გამოქვეყნებული იყო სხვა გამოცემებში.

აღნიშნული წესების დარღვევის შემთხვევაში სტატიები არ განიხილება.

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EXPERIENCE OF IMPLEMENTING DIGITAL TELEMEDICINE TECHNOLOGIES TO IMPROVE ACCESS TO CERVICAL CANCER SCREENING IN RURAL AREAS OF THE REPUBLIC OF KAZAKHSTAN

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Abstract.

Introduction: Cervical cancer (CC) remains one of the leading causes of cancer-related mortality among women in Kazakhstan, particularly in rural areas where access to preventive measures is limited. The aim of this study was to assess the effectiveness of a digital screening model for CC implemented in rural settings, compared to standard practice.

Materials and Methods: The study was conducted in Almaty region from 2018 to 2024 using a mixed design: a retrospective analysis of data on screening coverage, detection rates, and patient routing (2018–2022), and a cluster-randomized prospective study (2023–2024) with the implementation of digital solutions. In the intervention group, telemedicine, electronic registries, and an SMS notification system were implemented. The primary indicators included screening coverage, detection of pathologies, patient follow-up, and satisfaction measured using the PSQ-18 scale.

Results: In the intervention group, screening coverage reached 94.0% in urban and 90.0% in rural areas, compared to 92.0% and 88.0% respectively in the control group ($p < 0.001$). The detection rate of pathological changes was 15.0% in urban and 12.0% in rural areas in the intervention group, versus 13.0% and 10.0% in the control group ($p < 0.001$). The proportion of patients enrolled in follow-up among those with detected abnormalities was also higher in the intervention group: 75.0% in urban and 60.0% in rural areas, compared to 55.0% and 40.0% in the control group ($p = 0.0016$ and $p = 0.0011$, respectively). Satisfaction scores on the PSQ-18 scale were significantly higher in the intervention group in the following domains: technical quality (4.5 ± 0.4 vs 3.9 ± 0.7; $p = 0.001$), accessibility (4.5 ± 0.3 vs 3.7 ± 0.2; $p = 0.001$), and financial aspect (4.4 ± 0.4 vs 4.0 ± 0.7; $p = 0.023$).

Conclusion: The digital model for CC screening has proven effective in settings with limited access to healthcare. The results support scaling up this model within the national oncology strategy and contribute to achieving the global cervical cancer elimination targets.

Key words. Cervical cancer, mass screening, rural population, digital health, telemedicine, health services accessibility, Kazakhstan.

Introduction.

Cervical cancer (CC) is one of the most preventable forms of malignant neoplasms, yet it remains one of the leading causes of cancer-related mortality among women worldwide [1,2]. According to the World Health Organization, it is the fourth most common cancer in women, with approximately 660,000 new cases and around 350,000 deaths from CC registered globally in 2022 [3].

Approximately 94% of all deaths from CC occur in low- and middle-income countries, reflecting inequality in access to prevention and healthcare services [4]. At the global level, the issue of CC has prompted strategic action; in 2020, the WHO launched the Global Strategy to Accelerate the Elimination of Cervical Cancer, which sets the "90–70–90" targets by 2030 (90% coverage of HPV vaccination among girls, 70% screening coverage among women, and 90% access to treatment for precancerous lesions and invasive cancer) in order to eliminate CC as a public health problem [5].

In Kazakhstan, the incidence and mortality of CC remain among the highest in the region. CC ranks second among all malignant tumors in women, following only breast cancer [6,7]. According to estimates by the International Agency for Research on Cancer, about 1,700–1,800 new cases of cervical cancer are diagnosed annually in the country, and more than 800 women die from the disease [8].

CC accounts for a significant proportion of oncological morbidity among women of reproductive and working age; the highest mortality is observed in the 30–54 age group, which corresponds to the socially active period of life [9]. Despite some positive trends—recent years have seen a decline in CC mortality (from ~7.2 to ~5.9 per 100,000 women between 2013 and 2019) against the backdrop of screening program implementation—CC incidence in Kazakhstan remains consistently high (approximately 18–19 cases per 100,000 female population) [10].

Moreover, the coverage of preventive measures is significantly lower than recommended benchmarks, and organized screening covers only about 48–50% of the target group, whereas global experience indicates the need for at least 70% coverage to substantially reduce mortality [11].

For comparison, countries with well-established early detection programs have achieved a 50–75% reduction in CC mortality [12]. This situation highlights the need for further improvement of preventive measures, especially among undercovered population groups.

Of particular concern is the low accessibility of CC screening for the rural population of Kazakhstan [13]. More than 40% of

the country's population lives in rural areas, and it is precisely in these women that advanced-stage cases are often detected due to missed preventive examinations [13]. According to recent studies, participation in the screening program is significantly lower among rural women compared to urban women, with only about 38% of rural residents undergoing timely cytological testing, whereas this figure reaches 70–75% in cities. The coverage gap is caused by a combination of factors.

For example, geographic barriers play a significant role—many villages are located far from specialized medical centers, and poor road and transportation infrastructure hinder regular trips for smears and examinations [10]. Organizational barriers include a shortage of specialized professionals (obstetricians-gynecologists, cytopathologists) in rural areas and insufficient integration of rural healthcare into a unified oncological screening pathway. There is often no active invitation or reminder system for women about the need for screening; many rural women are unaware that the procedure is free and important [14].

According to local studies, lack of awareness and distrust in the necessity of screening are among the key reasons for refusal to participate in the program [15]. Cultural and psychological factors also play a role; for example, women may experience fear of cancer detection, shame, or discomfort during gynecological examinations, which is especially pronounced in small settlements [16].

Finally, digital barriers and limited communication infrastructure hinder the use of modern methods of remote consultation and monitoring [17]. In a number of remote areas, reliable internet is still lacking, and medical statistics are mainly kept on paper, which slows down data exchange and timely feedback to patients.

Kazakhstan is taking steps to improve the situation with cervical cancer at the national level [18]. Since 2008, a national cervical cancer screening program has been in place, under which women aged 30–70 are invited for preventive cytological examination (Pap smear) once every four years at primary care clinics based on their place of residence.

Screening is included in the guaranteed volume of free medical care, which allows for the examination of broad segments of the population. From 2016 to 2019, the State Health Development Program "Densaulyk" was implemented, one of the objectives of which was to improve oncological services and cancer prevention. During its implementation, the volume of screening studies in the country increased, with greater attention given to technical infrastructure and medical personnel.

Kazakhstan has taken a course toward the introduction of HPV vaccination and improving the effectiveness of screening, guided by international recommendations. In recent years, digital technologies have been introduced in healthcare, which may become key to overcoming a number of barriers [19]. For example, electronic screening registries are being developed to track each patient and automatically generate lists of those who did not attend their examination. The use of mobile applications and SMS notifications reminding women about doctor visits has begun [20].

Nevertheless, one of the promising directions is the development of a digital model of cervical cancer screening adapted to rural conditions.

The digital model implies the comprehensive use of information and communication technologies to improve all stages of the screening process – from active invitation and education of women to remote diagnostics and treatment monitoring [21].

Thus, this study aims to create and pilot an innovative digital approach to the early detection of cervical cancer, capable of overcoming existing geographical and organizational barriers. The implementation of this model in the long term will reduce morbidity and mortality from cervical cancer in rural communities, contribute to the overall improvement of women's health indicators in Kazakhstan, and bring the country closer to achieving the goals of the global strategy for the elimination of cervical cancer.

Materials and Methods.

Ethical Considerations:

The present study was approved by the Local Ethics Committee of the Kazakh National Medical University named after S.D. Asfendiyarov (Protocol No. 35 dated 12.05.2022). Participation in the study was voluntary, with informed consent obtained in advance.

Study design:

The study employs a mixed design incorporating both observational and interventional components.

In the first stage, a retrospective analysis was conducted using data from the existing cervical cancer screening program in rural and urban areas (to assess baseline effectiveness and identify access-related issues).

In the second stage, a prospective study with quasi-experimental elements (a cluster randomized controlled trial) was carried out to implement a digital solution within primary healthcare settings.

The study design and description were developed in accordance with international standards: the main components of the IMRAD structure were followed, and reporting was prepared based on the STROBE guidelines (for observational data) and CONSORT guidelines (for interventional components) [22].

Participants and Study Conditions:

The analysis was conducted in rural districts of the Almaty region (Republic of Kazakhstan), where access to screening is geographically limited. The retrospective component included aggregated data of all women in the target age group for screening (e.g., 30–70 years) over the past five years (2018–2022) in this region.

In the second (prospective) part of the study, the subjects were women of the same age range eligible for screening during the intervention period (e.g., 2023–2024) and registered with participating primary healthcare organizations (PHC) in rural areas.

Inclusion Criteria:

Women residing in rural areas, belonging to the target screening group according to the national protocol (no contraindications to screening, no history of invasive cervical cancer).

Exclusion Criteria:

Women who had previously undergone screening in the current cycle (to avoid duplication) or those who refused to participate.

Study Sample:

A cluster-based approach was used for the interventional component. Twenty rural outpatient clinics (PHC) in the Almaty region were randomly divided into two groups (intervention and control).

Each clinic cluster included all women of the target age category registered with that clinic. Cluster distribution was chosen to avoid "cross-contamination" between groups, as the intervention was implemented at the clinic level.

Randomization was performed using random number generation; neither participants nor physicians were blinded due to the nature of the intervention.

All participants in both the intervention and control groups received standard screening services; the differences were limited to the additional digital services in the intervention group.

Description of the Digital Intervention:

A comprehensive digital solution for screening was implemented in the intervention group of PHC organizations (Figure 1).

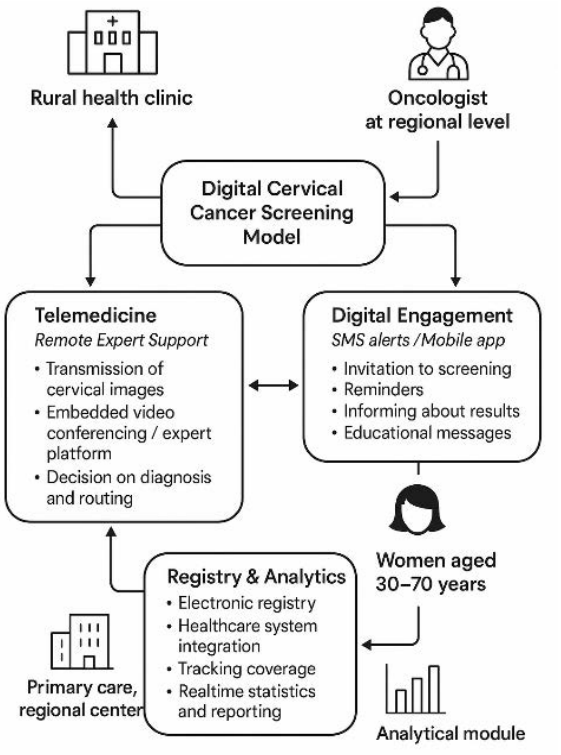

Figure 1. *Comprehensive Digital Solution for Screening.*

It included: (1) a telemedicine system for remote consultation and decision-making support – feldshers and obstetrician-gynecologists of rural outpatient clinics could transmit examination results (cervical images from visual inspections) to specialists at the regional oncology dispensary for remote assessment; (2) an electronic call and reminder system – a mobile application and SMS notifications were developed to invite women to screening, remind them of visits, and notify them of the need for follow-up if results were positive. This system also provided educational messages about the importance of screening; (3) digitalization of record-keeping and monitoring – an electronic screening registry integrated with the regional health information system was implemented in rural clinics, allowing real-time tracking of coverage and outcomes.

In the control clinics, standard screening practices continued (invitations for examinations were made through regular means of communication or during visits, telemedicine support was absent, and record-keeping was done on paper with subsequent periodic aggregation).

Data Collection:

Retrospective data were obtained from the "Healthcare Statistics" database of the S. Kairbekova National Scientific Center for Health Development. For each year from 2018 to 2022, information was collected on the number of women subject to screening in rural areas, the number who actually underwent screening, and the number of identified pathological cases.

In turn, during the implementation period (2023–2024), prospective data were collected quarterly from each participating polyclinic, including the screening coverage among women in the target group, the number of positive findings (suspicion of dysplasia or cancer), and subsequent steps (attendance for confirmatory diagnostics, initiation of treatment). In the intervention clinics, additional data on the performance of the digital system (number of invitations sent, number of telemedicine consultations, percentage of women who responded to SMS messages) were recorded for process evaluation of the intervention.

All data were recorded in electronic forms; for the intervention clinics, a new electronic registry was used, while for the control clinics, their routine reporting data were manually entered by the researchers into a standardized electronic table. Data quality was ensured through selective verification (audit of medical records) to assess completeness and accuracy.

Variables and Indicators:

The main explanatory variables were assignment to the intervention or control group (presence of digital support for screening) and type of district (rural or urban, for retrospective interregional analysis).

The primary outcome was screening coverage, defined as the percentage of women in the target group who underwent screening within a given period. This indicator was calculated for each district/clinic and compared with the WHO-recommended target level of ≥70%.

Secondary indicators for assessing satisfaction included the validated PSQ-18 questionnaire, which covers 7 domains (quality, accessibility, communication, etc.) on a 5-point scale. The survey was conducted among 458 female patients; 227 questionnaires from the intervention group and 231 from the control group were analyzed. Data were collected anonymously. The results were used for intergroup and temporal comparison of screening perception.

Statistical Analysis:

Statistical analysis was performed using IBM SPSS Statistics v.26.0. Categorical variables are presented as absolute and relative frequencies (%), and continuous variables as mean ±

standard deviation. Differences between groups were assessed using the χ^2 test or Student's t-test, depending on the distribution. Statistical significance was defined as $p < 0.05$. ANOVA and post hoc Bonferroni correction were used for comparison of proportions across years and between groups.

Results.

Between 2018 and 2022, data on women who underwent screening in Almaty Region were analysed (Table 1). During this period, screening coverage, detection rate of pathologies, and the proportion of women placed under medical supervision were consistently higher in urban areas compared to rural ones. The average screening coverage in urban areas was 89.7%, while in rural areas it was 78.0% ($p = 0.0056$).

The detection rate of pathological changes among those examined reached 12.7% in urban areas and 10.8% in rural areas ($p = 0.0012$). The proportion of women placed under medical supervision after detection was also higher in urban areas—58.7% versus 49.9% in rural areas ($p = 0.0021$). In 2022, despite the increase in rural screening coverage to 88.9%, the rate of medical follow-up decreased to 29.9%, whereas in urban areas it was 42.1%, confirming a persistent gap in the completion of the screening pathway.

It should be noted that during the period from 2018 to 2022, between 43,068 and 49,907 women were examined annually in rural areas of the Almaty region (Table 2), and between 28,712 and 33,271 in urban areas. The average number of normal cytological smears amounted to 30,663.4 in rural areas and 20,442.0 in urban areas. Cases of microorganisms detected in smears averaged 7,535.0 in rural areas and 5,023.2 in urban areas.

The number of other epithelial cell changes averaged 1,787.6 in rural areas and 2,184.6 in urban areas. The ASC-US indicator ranged from 990 to 1,128 in rural areas and from 1,210 to 1,379 in urban areas, with average values of 1,057.8 and 1,292.6, respectively. For ASC-H, there were between 184 and 216 cases annually in rural areas, and between 225 and 265 in urban areas, with average values of 196.2 and 240.2. LSIL cases ranged from 1,323 to 1,494 in rural areas and from 1,616 to 1,827 in urban areas, with average values of 1,412.6 and 1,722.6. HSIL was identified on average in 547.2 cases in rural areas and 630.6 in urban areas.

The number of detected carcinoma in situ (CIS) cells was minimal: from 0 to 2 cases annually in both types of areas. Endometrial cells in women over 40 years of age were recorded on average in 292.0 cases in rural areas and 349.8 in urban areas. The number of atypical glandular cells (AGC) averaged 68.2 in rural areas and 91.8 in urban areas. AIS was detected on average in 5.8 cases in rural areas and 11.4 in urban areas.

A comparative analysis showed statistically significant differences between urban and rural areas for all cytological indicators ($p < 0.001$). Urban areas consistently recorded higher values for all abnormal results, including ASC-US, ASC-H, LSIL, HSIL, AGC, and AIS.

In the second block of the study, an analysis of the results from a prospective study using digital solutions within a cluster design was conducted. The study included data from 2023–2024 (Table 3), collected from 20 PHC institutions in the Almaty region, randomly assigned into intervention and control groups.

In total, 32,573 women were screened in the intervention group over two years, and 25,056 in the control group. In 2023, 15,034 women underwent screening in the intervention group, of whom 6,314 (42%) resided in urban areas and 8,720 (58%) in rural areas. In the control group for the same period, 12,027 women were screened: 7,324 (60.9%) from urban areas and 4,703 (39.1%) from rural areas. The intergroup differences in geographical distribution in 2023 were statistically significant ($p = 0.026$).

In 2024, the intervention group demonstrated an increase in overall coverage — 17,539 women were screened, of whom 9,752 (55.6%) were from urban areas and 7,787 (44.4%) from rural areas. In the control group in 2024, 13,029 women were screened, with a distribution of 5,891 (45.2%) urban and 7,138 (54.8%) rural. During this period, the differences in distribution between groups were not statistically significant ($p = 0.123$).

However, a year-by-year analysis within each group revealed significant changes. In the intervention group, the proportion of urban patients among those screened significantly increased from 42% in 2023 to 55.6% in 2024 ($p = 0.047$), whereas in the control group the opposite trend was observed — the share of urban women decreased from 60.9% to 45.2% ($p = 0.001$).

In 2023, in the intervention group (Table 4), screening coverage in urban areas was 94.0%, and in rural areas — 90.0%. In the control group, these indicators were lower: 92.0% in urban areas and 88.0% in rural areas. The same difference persisted in 2024: 94.0% and 90.0% versus 92.0% and 88.0%, respectively. On average over the two years, coverage in the intervention group was 94.0% in urban areas compared to 92.0% in the control group ($p < 0.001$), and 90.0% versus 88.0% in rural areas ($p < 0.001$).

The detection rate was also higher in the intervention group: on average, 15.0% in urban areas and 12.0% in rural areas, whereas in the control group — 13.0% and 10.0%, respectively. The differences in detection rates between the groups were statistically significant both in urban ($p < 0.001$) and rural areas ($p < 0.001$).

The proportion of those enrolled for follow-up among the detected cases also differed: in the intervention group, it averaged 75.0% in urban areas and 60.0% in rural areas, while in the control group — 55.0% in urban areas and 40.0% in rural areas. The difference between the intervention and control groups for this indicator was +20 percentage points for urban areas ($p = 0.0016$) and +20 percentage points for rural areas ($p = 0.0011$).

As part of the survey (Table 5) conducted among 458 female patients, 227 questionnaires from the intervention group and 231 from the control group were analysed. Satisfaction was assessed using the PSQ-18 scale, which includes seven domains.

The mean score for overall satisfaction in the intervention group was 4.6 ± 0.3, which was statistically significantly higher than in the control group — 4.2 ± 0.5 ($p = 0.045$). In the "technical quality" domain, the intervention group also demonstrated a significant advantage: 4.5 ± 0.4 versus 3.9 ± 0.7 ($p = 0.001$). Similar differences were observed in the domains of "financial aspect" (4.4 ± 0.4 versus 4.0 ± 0.7, $p = 0.023$) and "accessibility" (4.5 ± 0.3 versus 3.7 ± 0.2, $p = 0.001$).

Table 1. *Cervical Cancer Screening Indicators in Almaty Region for 2018–2022.*

Year	Area	Eligible for Screening	Screened	Coverage (%)	Cases Detected	% Detected	Registered for Follow-up	% Registered
2018	Rural	58261	40583	69,7	3463	8,5	1662	48,0
	Urban	38841	31197	80,3	2997	9,6	1697	56,6
2019	Rural	57592	42000	72,9	4120	9,8	2175	52,8
	Urban	38395	32880	85,7	3742	11,4	2149	57,4
2020	Rural	56819	43000	75,7	4712	11,0	2600	55,2
	Urban	37879	34900	92,2	4636	13,3	3008	64,9
2021	Rural	56313	46600	82,7	6080	13,0	3880	63,8
	Urban	37542	36555	97,4	5561	15,2	4024	72,3
2022	Rural	50160	44600	88,9	5220	11,7	1560	29,9
	Urban	33440	31058	92,9	4312	13,9	1814	42,1

Table 2. *Cytological results of cervical cancer screening patients in Almaty region (2018–2022).*

Year	Area	Examined	Normal	Microorg.	Other changes	ASC-US	ASC-H	LSIL	HSIL	CIS	Endometrial cells 40+	AGC	AIS
2018	Rural	43068	28675	7066	1673	990	184	1323	512	0	270	63	5
	Urban	28712	19116	4710	2045	1210	225	1616	626	0	329	77	6
2019	Rural	44928	29913	7370	1746	1033	192	1380	534	0	281	66	5
	Urban	29952	19942	4914	2133	1262	235	1686	653	0	344	80	6
2020	Rural	46740	31120	7667	1816	1075	200	1436	556	0	292	68	5
	Urban	31160	20746	5112	2219	1313	244	1754	679	0	358	84	7
2021	Rural	49907	34896	7465	1939	1128	216	1494	543	2	223	106	8
	Urban	33271	23264	4976	2369	1379	265	1827	663	2	273	130	10
2022	Rural	45403	28713	8107	1764	1063	189	1430	585	1	364	38	4
	Urban	30269	19142	5404	2157	1299	232	1747	716	2	445	47	6

**ASC-US — atypical squamous cells of undetermined significance. ASC-H — atypical squamous cells – cannot exclude HSIL. LSIL — low-grade squamous intraepithelial lesion. HSIL — high-grade squamous intraepithelial lesion. AGC — atypical glandular cells. AIS — adenocarcinoma in situ.*

Table 3. *Geographic distribution of women who underwent screening in the intervention and control groups (2023–2024) and intergroup differences.*

Year	Intervention group n (%)		Total	Control group N (%)		Total	P value
	Urban	Rural		Urban	Rural		
2023	6314 (42)	8720 (58)	15034	7324 (60.9)	4703 (39.1)	12027	0.026*
2024	9752 (55.6)	7787 (44.4)	17539	5891 (45.2)	7138 (54.8)	13029	0.123
P value	0,047*		32573	0,001*		25056	

Table 4. *Screening Indicators After the Implementation of the Digital Intervention (2023–2024).*

Indicator	2023				2024			
	Intervention group		Control group		Intervention group		Control group	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Targeted for screening	6314	8720	7324	4703	9752	7787	5891	7138
Screened	5935	7848	6738	4139	9167	7008	5420	6281
Coverage (%)	94	90	92	88	94	90	92	88
Diagnosed cases, (%)	890 (15)	942 (12)	876 (13)	414 (10)	1375 (15)	841 (12)	705 (13)	628 (10)
Registered for follow-up, (%)	668 (75.1)	565 (60)	482 (55)	166 (40.1)	1031 (75)	505 (60)	388 (55)	251 (40)

Table 5. *Patient Satisfaction Assessment According to the PSQ-18 Scale.*

Indicator	Intervention	Control	p-value
Overall satisfaction	4.6±0.3	4.2±0.5	0.045*
Technical quality	4.5±0.4	3.9±0.7	0.001*
Courtesy and politeness	4.7±0.2	4.5±0.1	0.125
Communication	4.6±1.1	4.2±0.8	0.457
Financial aspect	4.4±0.4	4.0±0.7	0.023*
Time spent with physician	3.8±0.6	4.5±0.1	0.001*
Accessibility	4.5±0.3	3.7±0.2	0.001*

Conversely, for the "time spent with doctor" indicator, higher scores were reported in the control group — 4.5 ± 0.1 compared to 3.8 ± 0.6 in the intervention group (p = 0.001), which may be associated with workload redistribution under digitalization and remote consultations.

In the remaining domains — "courtesy and politeness" (4.7 ± 0.2 vs. 4.5 ± 0.1; p = 0.125) and "communication" (4.6 ± 1.1 vs. 4.2 ± 0.8; p = 0.457) — no statistically significant differences between the groups were observed.

Discussion.

The present study enabled a comprehensive assessment of the effectiveness of a digital cervical cancer screening model in rural regions of Kazakhstan, revealing statistically significant differences between the control and intervention groups in both screening coverage and detection indicators.

Analysis over a five-year period showed that the average screening coverage in urban areas of the Almaty region was 89.7%, while in rural areas it was 78.0% (p = 0.0056). Throughout all years, urban areas consistently showed higher coverage: in 2021, it reached 97.4% in urban areas compared to 82.7% in rural areas; in 2022 – 92.9% versus 88.9%. These figures indicate persistent inequality in access to preventive services between urban and rural territories. The gap is explained by a combination of factors: transportation remoteness of villages from screening points, shortage of personnel in primary healthcare, and low awareness among the rural population [23,24]. Comparable disparities by urbanization and screening accessibility were also observed, for instance, in India [25], where urban coverage exceeded 80%, while in rural areas it ranged between 50–60%, which is similar to our findings.

In our study, the proportion of detected pathological changes among screened women was higher in urban areas (12.7%) compared to rural areas (10.8%), p = 0.0012. A difference was also noted in patient registration for follow-up: in urban areas, 58.7% of detected patients were enrolled, whereas in rural areas – 49.9% (p = 0.0021). Despite the increase in rural screening coverage to 88.9% in 2022, the proportion enrolled for follow-up declined to 29.9%, while in urban areas it remained at 42.1%. This indicates a disruption in the continuity of the screening pathway in rural areas. Causes include poor routing after initial detection (absence of an automated referral system), lack of oncogynecologists and cytopathologists, and weak integration of primary care into the oncological network [26]. A similar situation is observed in other Central Asian countries: in Kyrgyzstan and Uzbekistan, follow-up care in rural areas accounts for less than 50% of detected cases [27].

A comparative analysis of cytological smears demonstrated that a higher number of all types of epithelial abnormalities were registered in urban areas. The average number of ASC-US cases in urban areas was 1292.6 compared to 1057.8 in rural areas; HSIL — 630.6 versus 547.2; AGC — 91.8 versus 68.2. For all indicators, the difference between urban and rural settings was statistically significant (p < 0.001). These differences reflect not only the true epidemiological distribution but also the variability in smear collection and interpretation quality. In rural areas, manual staining methods are more commonly used, and double verification is often lacking, which reduces the diagnostic sensitivity. In resource-limited countries, the sensitivity of the cytological method can range from 55% to 70%, depending on the personnel's qualifications and smear sampling standards [28].

The intervention group, where the digital model was implemented (telemedicine, electronic reminders, digital registry), demonstrated higher coverage: on average, 94% in urban areas and 90% in rural areas, whereas in the control group — 92% and 88% respectively (p < 0.001). These data confirm that the digitalization of processes leads to improved accessibility of services. In particular, SMS notifications and telemedicine consultations help compensate for staffing and transportation limitations [29]. Similar results were demonstrated in a study conducted in Uganda, where the introduction of mHealth applications increased screening coverage in rural areas [30].

In the intervention group, the detection rate was 15% in urban and 12% in rural areas, compared to 13% and 10% respectively in the control group (p < 0.001). The proportion of women enrolled for follow-up among those with positive findings was also higher in the intervention group: 75% in urban vs. 55% in control (p = 0.0016), and 60% in rural vs. 40% (p = 0.0011). The increase in these indicators is associated with the implementation of an automated electronic referral system: patients with positive results were automatically placed on a list for follow-up visits. Similar improvements in routing were described in a pilot program in Rwanda [31], where electronic registration helped reduce the proportion of those lost to follow-up by 35%.

In 2023, 42% of urban and 58% of rural women were screened in the intervention group, while in 2024 — 55.6% of urban and 44.4% of rural women. In the control group, the opposite trend was observed: the proportion of urban women decreased from 60.9% to 45.2%. These differences are statistically significant (p < 0.05) and demonstrate that digital methods more effectively stimulate participation among urban populations. This may be due to better access to mobile networks and the internet, as well as higher levels of digital literacy. A previous study also noted that engagement in digital programs is higher among women with urban employment and secondary/higher education [32].

The average score of overall satisfaction with the screening process in the intervention group was 4.6 ± 0.3 compared to 4.2 ± 0.5 in the control group (p = 0.045). In domains such as "technical quality," "financial aspect," and "accessibility," the intervention group also showed statistically significant advantages. The only exception was the "time with physician" domain, which was higher in the control group (4.5 ± 0.1 vs. 3.8 ± 0.6; p = 0.001). In our opinion, this is explained by the fact that the digital model optimized logistics but reduced the duration of personal contact. Comparable findings were obtained in a study where the implementation of telemedicine increased the efficiency of care pathways but reduced subjective satisfaction with consultation time [33].

Limitations of the Study.

The study is limited to the geographic area of a single region (Almaty region), which reduces the generalizability of the results to other areas of Kazakhstan. The absence of blinding for participants and physicians could have influenced behavioral

aspects and perceptions of quality. Data in the control group were partially collected manually, which potentially increases the risk of information bias. Furthermore, a long-term analysis of the intervention's impact on cancer incidence and mortality was not conducted.

Conclusion.

The digital screening model implemented in rural areas of the Almaty region demonstrated a significant increase in coverage (up to 90.0% in rural areas and 94.0% in urban areas), detection rate of pathologies (12–15%), and the proportion of women enrolled for follow-up (60.0% in rural areas and 75.0% in urban areas) compared to the control group. The use of telemedicine, electronic registries, and SMS notification systems led to improvements at all stages of the screening process. Patient satisfaction in the intervention group was higher across key PSQ-18 domains, including technical quality, accessibility, and financial aspects. The results confirm the effectiveness of the digital approach in overcoming organizational and geographic barriers and justify its further scaling as part of the national strategy to reduce cervical cancer incidence and mortality.

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