No 175 (175) (2025)

The scientific heritage
(Budapest, Hungary)
The journal is registered and published in Hungary.
The journal publishes scientific studies, reports and reports about achievements in different scientific fields.
Journal is published in English, Hungarian, Polish, Russian, Ukrainian, German and French.
Articles are accepted each month.
Frequency: 24 issues per year.
Format - A4
ISSN 9215 — 0365

«The scientific heritage»
Editorial board address: Budapest, Kossuth Lajos utca 84,1204
E-mail: public@tsh-journal.com
Web: www.tsh-journal.com

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ХІМІОТЕРАПІЯ ВИНОГРАДУ *IN VITRO*

Зеленянська Н.М.,
доктор сільськогосподарських наук, старший науковий співробітник, заступник директора з науково-інноваційної діяльності
Національний науковий центр «Інститут виноградарства і виноробства імені В.Є. Таїрова» НААН України
Рябий М.І.
Аспірант,
Національний науковий центр «Інститут виноградарства і виноробства імені В.Є. Таїрова» НААН України

CHEMOTHERAPY OF GRAPEVINE *IN VITRO*

Zelenianska N.
Doctor of Agricultural Sciences, Senior Research Scientist,
Deputy Director for Research and Innovation,
National Scientific Centre «V.Ye. Tairov Institute of Viticulture and Winemaking» NAAS of Ukraine
Riabyi M.
Graduate Student,
National Scientific Centre «V.Ye. Tairov Institute of Viticulture and Winemaking» NAAS of Ukraine
DOI: 10.5281/zenodo.18077199

Анотація

Метою даного дослідження було оцінити ефективність хіміотерапії з використанням препаратів Рибавірин, Озельтамівір для елімінації вірусу хвороби скручування листя (*Grapevine leafroll associated virus-3*, GLRaV-3) у рослин *Vitis vinifera* L. сорту «Одеський чорний» та визначити вплив віруцидних препаратів на розвиток ініціальних експлантів, мікроклонів винограду в умовах культури *in vitro*. З кущів винограду з візуальними проявами хвороби скручування листя було відібрано зразки, які використали для проведення лабораторної діагностики методом ІФА і підтверджено зараження вихідного матеріалу *GLRaV-3*. Інфіковані ініціальні експланти було введено в культуру *in vitro* та піддано хіміотерапії протягом 90 днів із використанням різних концентрацій препаратів. Після завершення процесу хіміотерапії оцінювали життєздатність рослин, морфогенетичні показники та коефіцієнт елімінації вірусу. Додатковий контроль дієвості процесу оздоровлення проводили через 180 днів.

Отримані результати показали суттєві відмінності між препаратами за рівнем фітотоксичності та віруцидної активності. Рибавірин у концентраціях 15–25 мг/л виявив підвищену токсичність для рослин, що проявилося в зниженні ростових показників і низькому рівні елімінації *GLRaV-3* (24,7–30,5%). На відміну від нього, Озельтамівір характеризувався значно кращою толерантністю рослин і високим коефіцієнтом елімінації – від 80,0 до 89,5 % залежно від концентрації. Найвищу ефективність отримано у варіантах із комбінованим застосуванням препаратів, де рівень елімінації був у межах 90,5–92,0% і залишався стабільним через 180 днів після завершення хіміотерапії. Отримані результати можуть бути використані у програмах оздоровлення виноградних генотипів та створення безвірусного садивного матеріалу.

Abstract

The aim of this study was to evaluate the effectiveness of chemotherapy using Ribavirin and Oseltamivir for the elimination of Grapevine leafroll-associated virus-3 (GLRaV-3) in *Vitis vinifera* L. plants of the ‘Odeskyi Chornyi’ cultivar, as well as to determine the impact of these virucidal agents on the development of initial explants and microclones under in vitro culture conditions. Samples were collected from grapevine plants exhibiting visual symptoms of leafroll disease and subjected to ELISA-based laboratory diagnostics, which confirmed GLRaV-3 infection in the initial plant material. The infected initial explants were introduced into in vitro culture and exposed to chemotherapy for 90 days using various concentrations of the tested agents. Upon completion of chemotherapy, plant viability, morphogenetic parameters, and virus elimination rates were assessed. Additional verification of the recovery process was conducted 180 days later.

The results revealed substantial differences between the tested agents in terms of phytotoxicity and virucidal activity. Ribavirin at concentrations of 15–25 mg/L exhibited increased phytotoxicity, manifested by reduced growth parameters and low GLRaV-3 elimination rates (24.7–30.5%). In contrast, Oseltamivir demonstrated markedly higher plant tolerance and a significantly greater elimination rate—ranging from 80.0% to 89.5%, depending on concentration. The highest efficacy was observed in treatments combining both agents, where virus elimination reached 90.5–92.0% and remained stable 180 days after chemotherapy. These findings can be applied in programs aimed at the sanitation of grapevine genotypes and the production of virus-free planting material.

Ключові слова: садивний матеріал, ініціальні експланти, мікроклони, *GLRaV-3*, хіміотерапія, Рибавірин, Озельтамівір.

Keywords: planting material, initial explants, microclones, GLRaV-3, chemotherapy, Ribavirin, Oseltamivir.

Актуальність дослідження. Вірусні хвороби винограду можуть викликатися широким спектром патогенних агентів. Для культурних сортів *Vitis vinifera* L. встановлено наявність понад 80 різних вірусів [8, 6]. Частина з них особливо небезпечна через високу поширеність, виражену вірулентність та глобальне розповсюдження, що зумовлює необхідність застосування регламентованих заходів контролю. Зокрема, на рівні ЄС нормативні документи передбачають обов'язкову діагностику садивного матеріалу винограду на вірус коротковузля винограду (*GFLV*) та вірус мозаїки арабіса (*ArMV*) роду *Nepovirus*, а також на вірус скручування листя винограду 1 і 3 (*GLRaV-1* та *GLRaV-3*) роду *Ampelovirus* [*5,* 17].

Хворобу винограду, спричинену вірусом скручування листя (*GLRaV*) вважають однією з найнебезпечніших. Види вірусів, що її викликають, послідовно називають вірусом скручування листя винограду 1, вірусом скручування листя винограду 2 тощо (*GLRaV-1, GLRaV-2, GLRaV-n*). Усі віруси належать до роду *Ampelovirus*, за винятком *GLRaV-2 ma GLRaV-7*, які відносяться до родів *Closterovirus* та *Velarivirus*. Поширення цієї хвороби по всьому світу є результатом транспортування інфікованого вірусом рослинного матеріалу на регіональному, національному, континентальному та міжконтинентальному рівнях, оскільки хвороба передається через щеплення [*13, 4, 14*].

Перші ознаки хвороби, зокрема загинання країв листкових пластинок донизу, зазвичай проявляються на початку серпня та посилюються до кінця вегетації. У сортів із темним забарвленням ягід інфекція спричиняє передчасне почервоніння листків, при цьому зона вздовж головних жилок залишається зеленою. У сортів із світлими ягодами частіше спостерігають слабкий хлороз. Інтенсивність прояву симптомів залежить від генотипу сорту, кліматичних умов і типу збудника. Деякі серотипи *GLRaV* можуть викликати прихований, безсимптомний перебіг інфекції. Такі рослини часто залишаються зовні здоровими, але здатні передавати вірус при використанні їх у щепленні [*13*].

Інфікування вірусом скручування листя призводить до різкого зниження продуктивності виноградних насаджень. У хворих рослин формується дрібне гроно, ягоди повільніше забарвлюються, мають підвищену кислотність і нижчий вміст цукрів [*20, 14]*. За різними оцінками, втрати врожаю становлять від 20 до 40 % або навіть більше. Зменшення цукристості також негативно впливає на якість виноматеріалів: вина з таких ягід містять менше спирту, танінів, мають менш інтенсивне забарвлення та гірші смакові характеристики [*13, 16, 20, 6]*. Крім кількісних і якісних показників урожаю ягід ураження *GLRaV-3* суттєво зменшує площу листкової поверхні кущів винограду, метаболічну активність листків, інтенсивність росту пагонів, довжину міжвузлів, вихід стандартних чубуків та визрівання лози. У лозі накопичувалося на 40-43 % менше сухих речовин, порівняно із здоровими рослинами [19, 16, 20, 6]. А це агробіологічні показники росту та розвитку кущів винограду, які забезпечують розмноження виноградної лози у різні способи.

Для контролю хвороб винограду, спричинених вірусами вирішальне значення має використання здорового садивного матеріалу. Але, в окремих випадках, коли мова йде про збереження цінного генетичного матеріалу винограду, який уражений вірусом скручування листків винограду, необхідно проводити його оздоровлення. Для елімінації *GLRaV-3* рекомендують використовувати термотерапію, хіміотерапію, культивування апікальних меристем та соматичний ембріогенез. Проте, ефективність елімінації змінюється залежно від методу [7, 18, 2, 1].

Аналіз літературних джерел показує, що для оздоровлення винограду від хвороби *GLRaV-3* шляхом проведення хіміотерапії в культурі тканин і органів *in vitro* можна застосовувати низку віруцидних препаратів, зокрема Рибавірин (Ribavirin), 5-Азацитидин (AZA), Ациклогуанозин, Азидотимідин (AZT), 3-Деазауридин (DZD), DHPA (дигідроксіпропіладенін), Озельтамівір (Oseltamivir), Мікофенолову кислоту (MPA), Селеназол (SE), DHT (2,4-діоксо-гексагідро-1,2,5-тріазин), Ціаногуанідин та ін. [9, 10, 11, 12]. Але, одні препарати є недоступними в Україні, інші проявляють високу токсичність щодо розвитку ініціальних експлантів винограду *in vitro* або загалом не впливають на елімінацію *GLRaV-3*. Крім того, для кожного генотипу винограду слід поступово підбирати як віруцидні препарати, так і робочі концентрації для хіміотерапії, оскільки ефективність і фітотоксичність залежать від генотипу рослини господаря, типу вірусу та стану експланту.

Тому у даному дослідженні оцінювали оздоровлення винограду технічного сорту «Одеський чорний» під впливом противірусних реагентів – Рибавірину та Озельтамівіру. Подібних досліджень в Україні не проводили, тому їх актуальність залишається на високому рівні, а робота є своєчасною. Крім того, сорт «Одеський чорний» є цінним за своїми господарсько-біологічними ознаками, тому його клони потребують оздоровлення для подальшого збереження та використання у виробництві.

Мета дослідження – визначити вплив препаратів Рибавірин та Озельтамівір на елімінацію вірусу скручування листя винограду (*GLRaV-3*) та розвиток ініціальних експлантів, мікроклонів винограду в культурі *in vitro.*

Матеріали та методика дослідження. Робота виконувалась у лабораторії культури винограду *in vitro* відділу розсадництва, розмноження та біотехнології винограду Національного наукового центру «Інститут виноградарства і виноробства імені В. Є. Таїрова» НААН України протягом 2022–2025 рр. У роботу було взято мікроклональні рослини технічного сорту винограду «Одеський чорний».

«Одеський чорний» («Алікант Буше» х «Каберне Совіньйон») – технічний сорт винограду селекції ННЦ «ІВіВ ім. В. Є. Таїрова» середньопізнього строку дозрівання, відомий високою врожайністю, стійкістю до хвороб та морозостійкістю. З урожаю ягід отримують насичені рубінові вина з тонами пасльону, вишні, шоколаду та ягід. Використовують для виготовлення сухих, десертних та ігристих вин.

У польових умовах шляхом проведення візуальної селекції винограду були виявлені кущі з візуальними симптомами хвороби скручування листя винограду. З даних кущів було взято верхівки пагонів для введення у культуру тканин і органів *in vitro*, а також зразки для ідентифікації збудника хвороби скручування листя винограду шляхом лабораторного тестування. Ідентифікацію вірусу скручування листя винограду проводили методом імуноферментного аналізу (ІФА). Для цього використовували комерційні набори фірми *Agritest* (Італія) до вірусів скручування листя *GLRaV3* (*Grapevine Leaf Roll-Associated Virus 3*).

Ініціальні експланти, які використовували у роботі: одновічкові чубуки із бічною брунькою, верхівки пагонів (для введення в культуру *in vitro*) та сформовані мікроклони.

Ініціальні експланти (верхівки пагонів, розміром 0,8–1,0 см) сорту «Одеський чорний» *in vitro* культивували на модифікованому поживному середовищі Мурасіге і Скуга (MS), що містило: для введення в культуру *in vitro* – 0,5 мг/л 6-БАП і 0,1 мг/л ІОК, для мікророзмноження, укорінення – 0,2 мг/л 6-БАП і 0,3 мг/л ІОК, половинну кількість макросолей та хелату заліза. Фізичні параметри культивування: температура 24–25ºС, 16-годинний фотоперіод, освітлення 2500–3000 лк., вологість повітря 60–70 %.

Для проведення хіміотерапії у поживне середовище, перед автоклавуванням додавали віруцидні препарати – Рибавірин та Озельтамівір. Концентрації препаратів встановлювали на основі оцінки фітотоксичності та за умови не перевищення порогового рівня [18]. Хіміотерапію проводили протягом трьох пасажувань по 30 днів кожне (загалом 90 днів). Після чого рослини послідовно переносили на свіжі MS для мікророзмноження, укорінення та адаптації. Визначення коефіцієнту елімінації вірусу *GLRaV-3* проводили через 90 днів хіміотерапії та через 6 місяців після її завершення.

Роботу проводили за наступною *схемою досліду*:

Варіант 1 – Рибавірин, 15 мг/л;

Варіант 2 – Рибавірин, 20 мг/л;

Варіант 3 – Рибавірин, 25 мг/л;

Варіант 4 – Озельтамівір, 30 мг/л;

Варіант 5 – Озельтамівір, 40 мг/л;

Варіант 6 – Озельтамівір, 80 мг/л;

Варіант 7 – Рибавірин, 20 мг/л + Озельтамівір, 30 мг/;

Варіант 8 – Рибавірин, 20 мг/л + Озельтамівір, 40 мг/;

Варіант 9 – Контроль (культивування мікроклонів винограду без хіміотерапії).

Кількість ініціальних експлантів для кожного варіанту досліджень дорівнювала 15 шт.. Кожен експлант представляв одне повторення і оцінювався індивідуально.

Ініціальні експланти та сформовані рослини культивували у склянних ємкостях діаметром 40 мм, висотою 150 мм, об'єм поживного середовища дорівнював 20–25 мл. У цих ємкостях рослини знаходились і під час хіміотерапії.

У роботі використовували: мікробіологічні, молекулярно-біологічні та біотехнологічні методи досліджень. Визначали: кількість життєздатних мікропагонів (%), біометричні показники росту та розвитку вегетативної маси мікроклонів (кількість утворених пагонів, коренів (шт.), їх висоту та довжину (см), коефіцієнт елімінації (КЕ (%) = $(N_2/N_1)*100$, де N_1 – загальна кількість рослин, що проходили оздоровлення, шт.; N_2 – кількість оздоровлених рослин, шт.).

Результати дослідження та їх обговорення. Упродовж 2023–2025 рр. було проведено фітосанітарне обстеження виноградних насаджень південних районів Одеської області з метою виявлення вірусних інфекцій. У результаті обстежень на насадженнях сорту «Одеський чорний» були вичвлены кущі з характерними симптомами хвороби скручування листя винограду. Із цих рослин було відібрано зразки для лабораторного тестування, за результатами якого підтверджено наявність *GLRaV-3*. Вегетуючі пагони інфікованих кущів були використані для введення ініціальних експлантів у культуру *in vitro* з подальшим мікророзмноженням для отримання необхідної кількості мікроклонів для роботи.

Після отримання мікроклональних рослин, що за біометричними показниками відповідали повноцінним рослинам, їх живцювали на одновічкові чубуки (верхівкові сегменти) і висаджували на поживні середовища з віруцидними препаратами – Рибавірином та Озельтамівіром різних концентрацій. Кожне нове пасажування здійснювали тричі через кожні 30 днів та визначали рівень приживлюваності ініціальних експлантів (Рис. 1).

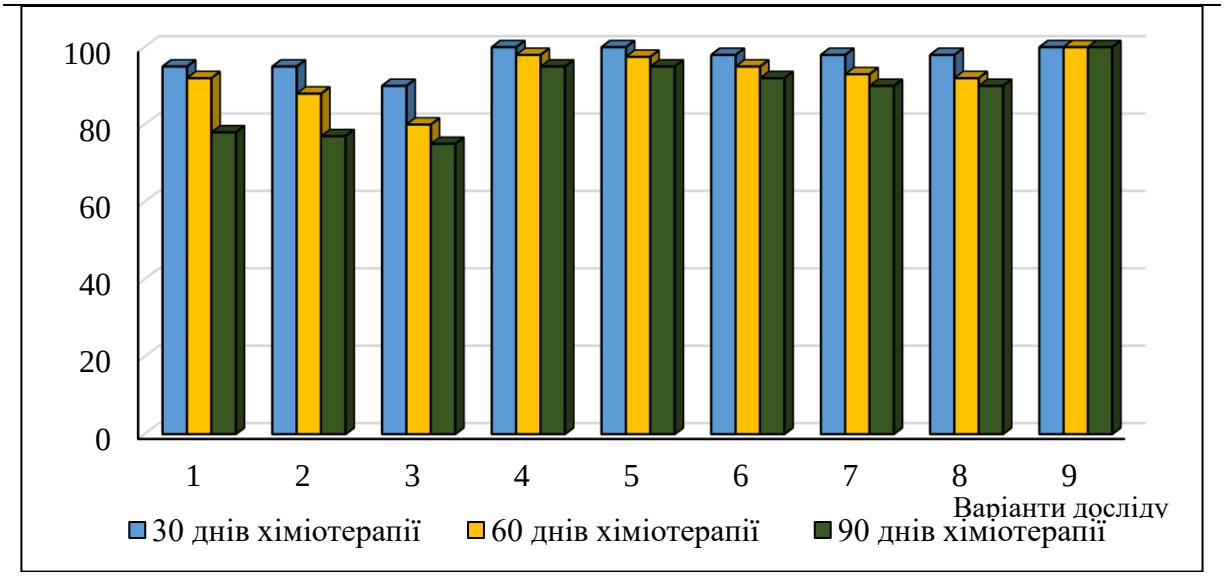

Рисунок 1. Життєздатність ініціальних експлантів винограду у різні строки проведення хіміотерапії, %

Життєздатними вважали експланти, які характеризувалися зеленою листковою пластинкою і тканинами чубуків, наявністю живої пазушної бруньки, її проліферацією, ризогенезом. Отримані дані показують, що ефективність хіміотерапевтичних препаратів залежала як від типу та концентрації препаратів, так і від тривалості проведення процесу. Після 30 днів хіміотерапії життєздатність мікроклонів у всіх варіантах залишалася високою (90–100 %). 100 % життєздатних ініціалей було після застосування Озельтамівіру 30 і 40 мг/л та у контролі (без впливу препаратів). У варіантах з Рибавірином (перший-третій) рівень життєздатності ініціалей дорівнював 90–95%. Це свідчить про те, що навіть короткотривалий вплив Рибавірину проявляє легкий стресовий ефект.

На 60-й день хіміотерапії різниця між варіантами досліду була більш вираженою. Найбільше життєздатних ініціалей (98–100%) було так само у варіантах з Озельтамівіром та контролі. У варіантах з Рибавірином рівень життєдіяльності ініціалей знижувася до 80–92%. У варіантах, де хіміотерапію проводили комплексно (Рибавірин+Озельтамівір) показники життєздатності були меншими (92–93%) проте стабільними. Це свідчить, що Озельтамівір у концентрації 30–40 мг/л проявляє незначну фітотоксичність навіть на 60 день хіміотерапії, порівняно з Рибавірином. Про істотне зниження швидкості розмноження та високу фітотоксичність Рибавірину високих концентрацій вказано і в дослідженні *Panattoni A. та ін.* (2014) [18]. Одночасне використання Рибавірину та Озельтамівіру для елімінації *GFkV* дозволило запустити процеси каулогенезу, і не було зареєстровано жодного відмирання експлантів після трьох послідовних субкультур. Це можна пояснити різним фітотоксичним ефектом віруцидів та різною стійкістю до них, регенеративним потенціалом досліджуваних генотипів винограду.

Через 90 днів хіміотерапії життєздатність ініціальних експлантів помітно знижувалася у всіх варіантах після застосування хіміотерапевтичних препаратів. Проте, найбільше життєздатних ініціальних експлантів було у контрольних варіантах та варіантах із Озельтамівіром 95% (30, 40 мг/л) та 92% (80 мг/л). У варіантах із Рибавірином життєздатність ініціалей зменшувалась до 75-78%, на відміну від варіантів, де хіміотерапію проводили з застосуванням двох препаратів: Рибавірин, 20 мг/л + Озельтамівір, 30 мг/; Рибавірин, 20 мг/л + Озельтамівір, 40 мг/л. Життєздатність ініціальних експлантів була на рівні 90%. У контрольному варіанті кількість життєздатних експлантів дорівнювала 100%, що абсолютно логічно, оскільки ініціале не піддавали впливу віруцидних препартів.

Отже, за критерієм життєздатності ініціальних експлантів винограду найбільш оптимальним для проведення хіміотерапії є препарат Озельтамівір у концентрації 30–40 мг/л, оскільки він проявляв меншу фітотоксичність. Проте, слід зазначити, що після комбінованого застосування обох препаратів у концентрації 20 та 40 мг/л показники життєздатності мікроживців винограду також були на високому рівні.

Незважаючи на тривале культивування мікроклонів винограду на поживних середовищах із віруцидними препаратами, які у різній мірі проявляли фітотоксичний ефект, рослин розвивалися і після завершення хіміотерапії характеризувалися достатніми біометричними показниками розвитку як вегетативної надземної маси, так і кореневої системи (Рис. 2).

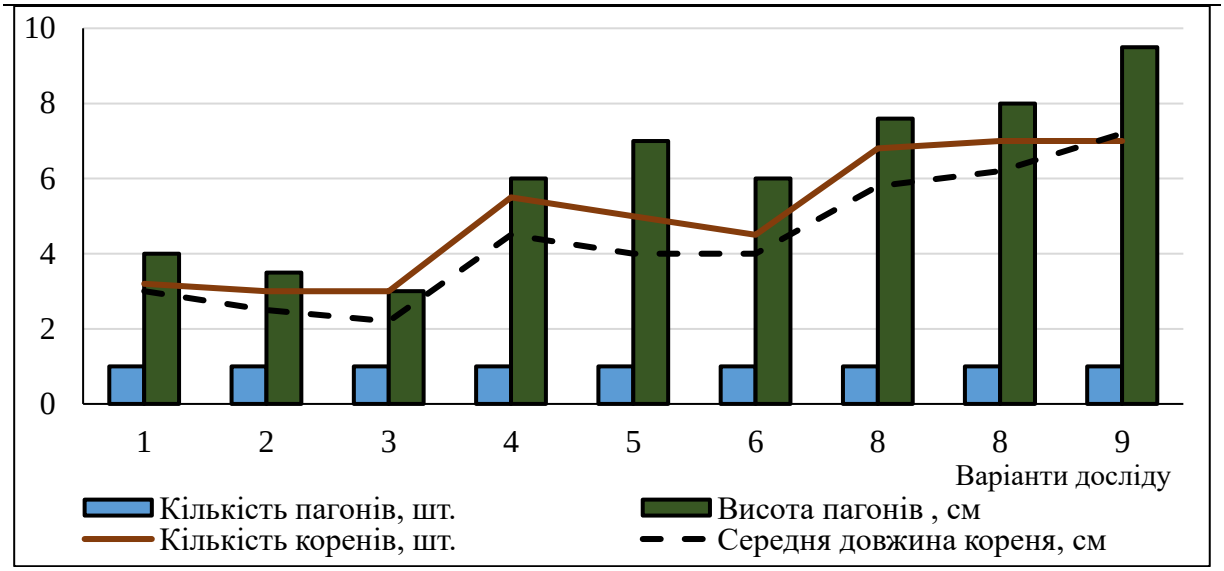

Рисунок 2. Біометричні показники росту та розвитку мікроклонів винограду після проведення хіміотерапії (90 днів)

У всіх варіантах досліду мікроклони формували по одному пагону, що свідчить про стабільність утворення пагонів незалежно від типу або концентрації хіміотерапевтичного препарату. Це дозволяє вважати, що препарати не пригнічували формування пагонів, а впливали здебільшого на їх ріст і розвиток. Висота пагонів змінювалась залежно від типу та концентрації препарату. Найменшу висоту мали рослини після застосування Рибавірину у концентраціях 20–25 мг/л (другий, третій варіанти), особливо після тривалої хіміотерапії. Озельтамівір, навпаки, стимулював ріст пагонів у порівнянні з Рибавірином. Після застосування Озельтаміміру у концентраціях 30, 40 мг/л, у т.ч. у комбінації з Рибавірином висота пагонів рослин дорівнювала 6,0–8,0 см. Про позитивний вплив сумісного застосування препаратів Рибавірин (невисокі концентрації) та Озельтамівір на інтенсивність проліферації адвентивних бруньок і подальший їх розвиток вказують дослідження і інших авторів [18, 9].

Аналіз показників ризогенезу показав тісний зв'язок між кількістю сформованих коренів та їх довжиною, що узгоджується із загальним рівнем життєздатності мікроклонів після хіміотерапії. Найменші значення обох показників встановлено у варіантах із Рибавірином: кількість коренів дорівнювала 3,0–3,2 шт., їх середня довжина – 2,2–2,5 см, що свідчить про ефект пригнічення препарату на розвиток кореневої системи. У рослин, які проходили хіміотерапію під впливом Озельтаміміру та його комбінації з Рибавірином кількість коренів збільшувалась до 4,5–6,0 шт., а середня довжина коренів – до 4,0–6,2 см. Ці значення є наближеними до контрольних показників.

Після завершення хіміотерапії з кожного варіанту було відібрано по 10 рослин для визначення ефективності елімінації *GLRaV-3* (рослини були окремо проаналізовані за допомогою *ELISA*). Результати визначення показали, що після проведення хіміотерапії рослини, вільні від *GLRaV-3*, були у всіх варіантах, за виключенням контролю. Проте кількість таких рослин була різною (Рис. 3).

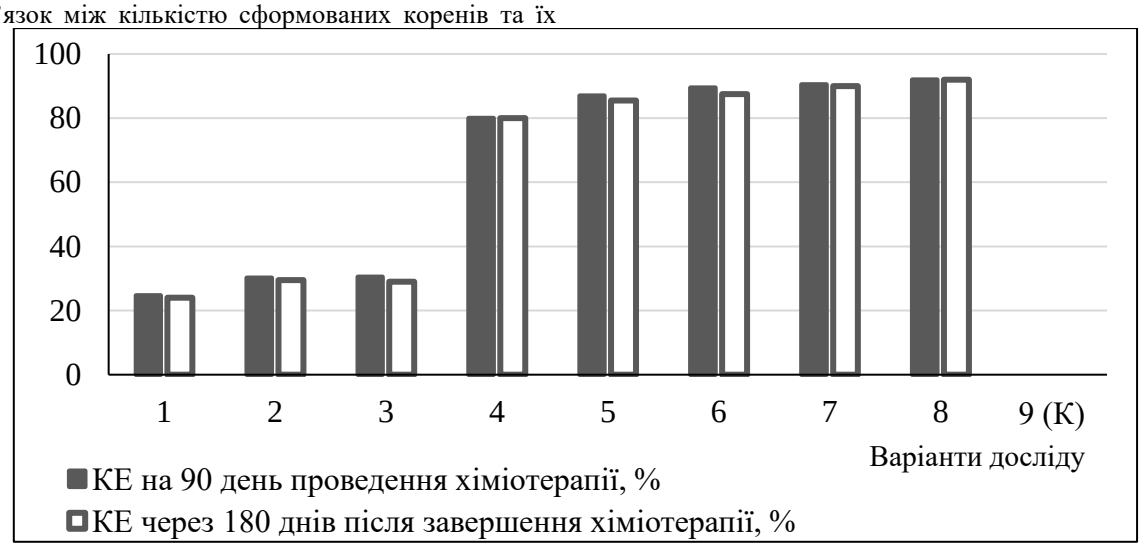

Рисунок 3. Коефіцієнт елімінації вірусу хвороби скручування листя винограду (GLRaV-3) після проведення хіміотерапії

Згідно з даними рис. 3 можна стверджувати, що ефективність хіміотерапії мікроклонів винограду істотно залежала від препарату, що застосовували для хіміотерапії. У варіантах з Рибавірином (перший–третій) коефіцієнт елімінації вірусу на 90-й день становив тільки 24,7–30,5%, що свідчить про слабкий противірусний ефект і збереження інфекції у більшості рослин. Подібні результати було отримано [3, 18] Через 180 днів після проведення хіміотерапії показники практично не змінилися, що підтверджує низьку ефективність препарату.

У варіантах з Озельтамівіром та його комбінаціях з Рибавірином (четвертий–восьмий) коефіцієнт елімінації вірусу був високим – 80–92%, через 180 днів культивування рослин у культуральному боксі він знижувався (у окремих варіантах) на 1,5 %. Це свідчить про стабільний і тривалий противірусний ефект препарату. Разом із тим, як зазначають інші дослідники, навіть за успішної елімінації вірусу в умовах *in vitro*, через 1–3 роки культивування мікроклональних рослин у неконтрольованих умовах довкілля необхідно проводити повторне тестування для підтвердження стабільності оздоровленого стану рослин [15]. Оскільки результат елімінації вірусу *GLRaV-3* встановлений на етапі культивування *in vitro*, не завжди підтверджується у подальших дослідженнях вже акліматизованих рослин.

Висновки. У результаті фітосанітарного обстеження та лабораторної діагностики (ІФА) встановлено інфікування рослин сорту «Одеський чорний» вірусом скручування листя винограду 3 (*GLRaV-3*). Виділені інфіковані пагони були введені в культуру *in vitro*, регенеровані мікроклони були використані як вихідний матеріал для хіміотерапії. Останню проводили з застосуванням препаратів Рибавірин та Озельтамівір протягом 90 днів.

Оцінка життєздатності ініціальних експлантів винограду залежала від препарату, його концентрації та тривалості експозиції. Після 30 днів хіміотерапії життєздатність залишалась високою у всіх варіантах досліду (90–100 %), проте вже на 60-й та 90-й день цей показник знижувався до 92 та 80%.

Препарат **Озельтамівір у концентраціях 30–40 мг/л проявляв низьку фітотоксичність протягом усього періоду хіміотерапії**, забезпечуючи 95–100% життєздатних експлантів навіть після 90 днів культивування. Це свідчить про його придатність для подальших досліджень з елімінації вірусу (*GLRaV-3*). Препарат **Рибавірин у концентраціях 15–25 мг/л проявляв високу фітотоксичність**. Після його застосування життєздатність експлантів зменшувалась до 75–78% після 90 днів хіміотерапії.

Комбіноване застосування Рибавірину (20 мг/л) та Озельтамівіру (30–40 мг/л) забезпечувало високі показники життєздатності (≈90 %) після 90 днів хіміотерапії, що може свідчити про синергічний або компенсаторний ефект препаратів і розширює можливості комбінованих схем оздоровлення.

Незважаючи на фітотоксичний вплив препаратів, мікроклональні рослини після завершення хіміотерапії зберігали здатність до активного росту, утворення пагонів та коренів. Це підтверджує, що віруцидні речовини у застосованих концентраціях не блокують відновлення регенераційних процесів рослин після оздоровлення.

Найвищий коефіцієнт елімінації *GLRaV-3* був отриманий у варіантах із комбінованим застосуванням Рибавірину та Озельтамівіру (КЕ = 90,5–92,0%) і залишався стабільним через 180 днів після завершення хіміотерапії. Тому, таку комбінацію можна застосовувати для елімінації *GLRaV-3* та формування оздоровленого вихідного матеріалу винограду.

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BIOLOGICAL SCIENCES

INNOVATIVE SOLUTIONS IN EGG PRODUCTION

Musin A.
Ph.D., AVNutriSmart LLC, General Director
Gadiev R.
Dr. Agricultural Sciences, Professor, Federal State Budgetary Educational Institution of Higher Education Bashkir State Agrarian University
Mustafin A.
Ph.D., Alltech LLC, Technical Consultant on Poultry Nutrition
Khaziev D.
Dr. Agricultural Sciences, Professor, Federal State Budgetary Educational Institution of Higher Education Bashkir State Agrarian University
DOI: 10.5281/zenodo.18077254

Abstract
The effect of the combined use of two forms of benzoic acid and mannanoligosaccharides on egg production and egg weight in chickens was studied. The effect of using the Sal-Zap organic acid complex at various dosages on quail egg weight was also studied. The results allowed us to determine the optimal dosages. A combination of 750 g of concentrated benzoic acid, 200 g/t of coated benzoic acid, and 400 g of Actigen per 1 ton of laying hens' feed demonstrated the most consistent results. A Sal-Zap dosage of 750 g/t in quail feed was determined to be the best. These levels can be recommended for nutritionists specializing in laying hens and quails.
Keywords: antibiotics, benzoic acid, coated benzoic acid, mannanoligosaccharides, Actigen, Sal-Zap, laying hens, laying rate.

In a number of countries, the use of antibiotics in poultry feed is prohibited by law unless it is used to treat diseases. Consequently, research into antibiotic substitutes has intensified. Promising alternatives include plant components and their derivatives, probiotics, prebiotics, and organic acids [1]. Organic acids have proven effective in optimizing gastrointestinal function. Scientific experiments have confirmed their positive impact on intestinal development and health in laying hens and male pigs [7]. The key advantage of organic acids as an alternative to antibiotics is their ability to act directly in feed by lowering pH [3]. This has a dual effect:

- improves nutrient absorption;
- suppresses pathogenic microorganisms both in feed and in the animal's digestive system [8].

Benzoic acid belongs to a group of simple aromatic carboxylic acids. Benzoic acid in broiler feed affects live weight gain and improves feed conversion. However, high doses of benzoic acid can negatively impact bird health and performance. Protected benzoic acid, which appears as white granules, unlike its concentrated, unprotected form, dissociates primarily in the lower intestine, maintaining a low pH in the duodenum and jejunum favorable for the beneficial microflora found in the small intestine [6].

Mannan oligosaccharides, derived from the outer walls of yeast cells, have a positive effect on the structure of intestinal villi and, as a result, on poultry performance. Over the past two decades, the problem of antibiotic resistance in pathogenic bacteria has prompted research and practice worldwide to develop numerous solutions to achieve production results without the use of feed antibiotics. One such product is Bio-Mos [9], and the next version of this product is Actigen – mannan-enriched fractions extracted from the Bio-Mos structure.

The complex acidifier Sal-Zap, a mixture of propionic, acetic, and sorbic acids, effectively combats pathogenic microflora entering the poultry body from outside. In the feed industry, animal proteins, particularly fishmeal, are one of the main sources of Salmonella. Sal-Zap has proven itself to be an effective inhibitor of pathogenic microflora growth during fishmeal production [2].

The literature we reviewed confirms the positive role of various feed additives that modulate the microbiota and villus structure of poultry intestines in increasing poultry productivity. However, the scientific literature lacks data emphasizing the comprehensive study of organic acids and mannanoligosaccharides in terms of their impact on egg production in laying hens, which underscores the novelty and relevance of our study.

The objective of the study was to evaluate the effect of organic acids and mannanoligosaccharides in compound feed for laying hens and quail on egg production.

To achieve this goal, the following **tasks** were set:

• To study the synergistic effect of benzoic acid in different forms, concentrated and coated, on egg production in laying hens;

• To study the possibility of achieving an enhancing effect by adding mannanoligosaccharides in combination with benzoic acid;

• To determine the effect of different doses of Sal-Zap on egg production in laying quail;

• To study the effect of the factors studied on egg weight.

Materials and Methods. Nine-month studies on laying hens were conducted in the experimental poultry house of the Bashkir State Agrarian University, Ufa, Republic of Bashkortostan, Russia, from early January

to late September 2025. Quail experiments were conducted from mid-March to late August 2025 at a quail farm in the Republic of Bashkortostan, Russia. The experiment lasted six months.

For the first experiment, four groups of SuperNik laying hens were randomly selected, each containing 42 birds. The birds were 245 days old at the beginning of the experiment. The second experiment was conducted on Manchurian quails. Fifty 46-day-old quail were selected.

The first experiment involved studying the productivity of laying hens using feed additives in the following combinations: 750 g of concentrated benzoic acid per ton of feed + 200 g/t coated benzoic acid were added to the diet of birds in a Treatment 1, while Treatment 2 group received 750 g of concentrated benzoic acid + 200 g/t coated benzoic acid + 400 g/t mannanoligosaccharides as Actigen. In the experiment on quail, different doses of the acidifier Sal-Zap were studied: Treatment 1 group received Sal-Zap in the amount of 500 g/t of feed, Treatment 2 group – 750 g/t, and Treatment 3 group – 1000 g/t.

Eggs were collected manually, recording daily collection from each group and maintaining a separate record of the number of eggs with cracks. The resulting digital data was processed using variation statistics using Microsoft Office Excel. The significance and magnitude of differences were assessed using Student's t-tests.

The study revealed a positive effect of using a combination of two forms of benzoic acid and the addition of mannanoligosaccharides on the egg production of laying hens (Figure 1). Birds in the Treatment 1, which received a mixture of protected and concentrated benzoic acid, showed a cumulative increase of 3.17% by the end of the experiment compared to the control group. Treatment 2 group outperformed the control group by 3.92%. Thus, we see that the addition of Actigen contributed to an additional productivity of 0.75% compared to the Treatment 1, which in absolute terms increased the gross harvest by 154 eggs (and +613 eggs vs. Control).

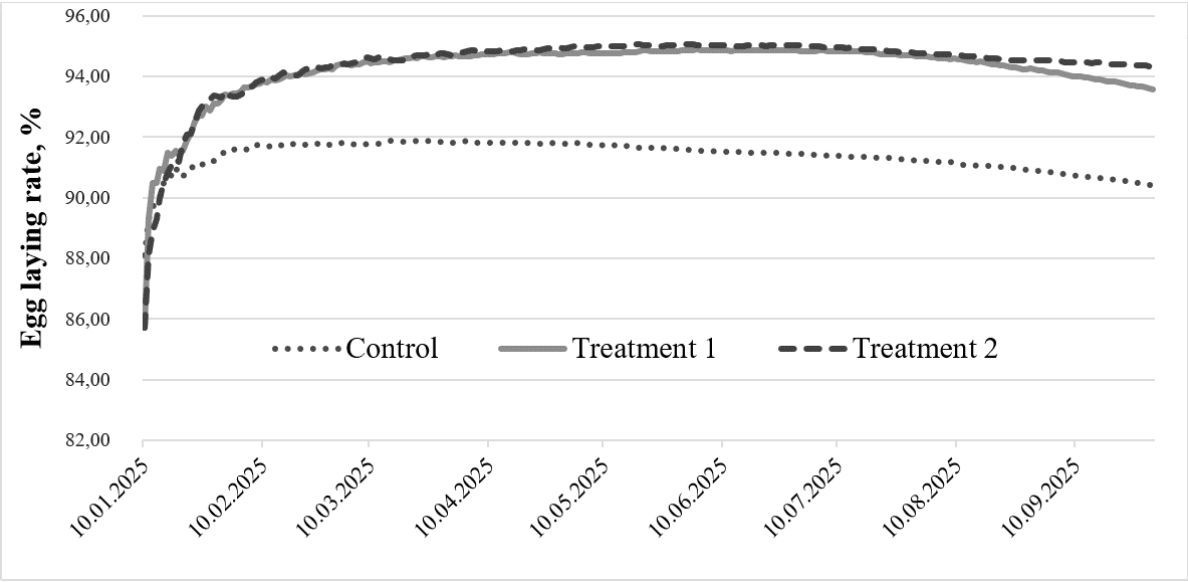


Figure 1. Cumulative egg production of laying hens, %

We noted a similar trend in the number of eggs with cracks: the largest proportion of cracks in the total egg collection was recorded in the control group, while Treatment 1 and Treatment 2 improved this indicator by 0.22% and 0.31%, respectively (Figure 2).

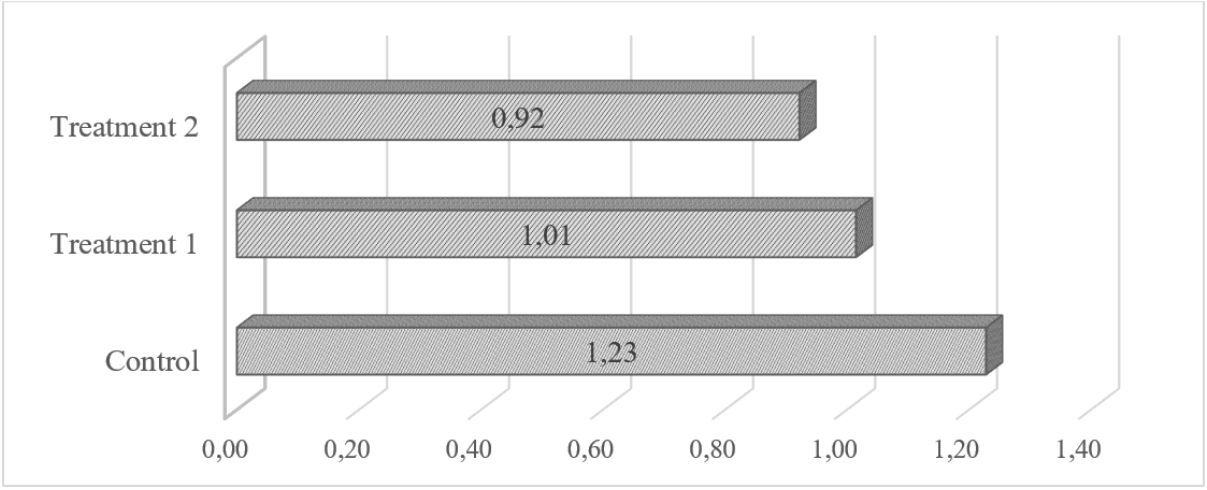
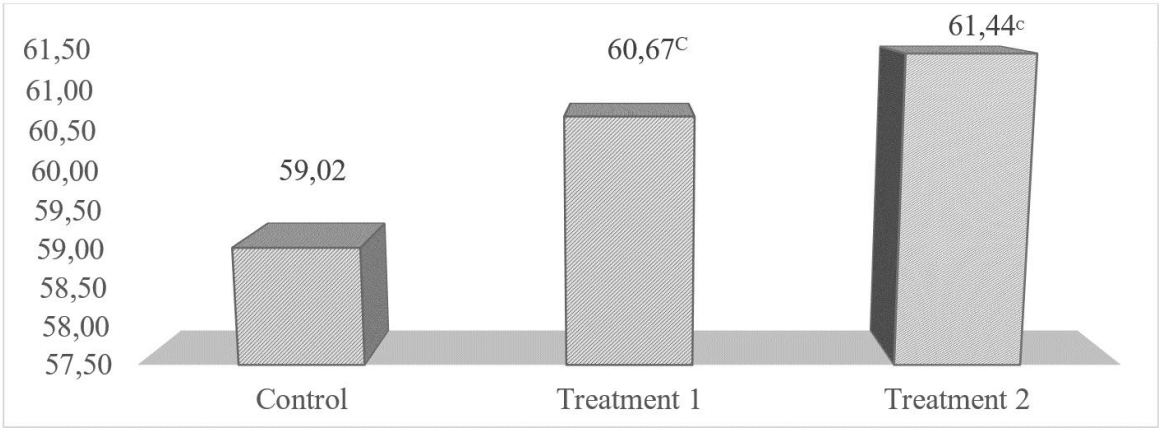


Figure 2. Crack, % of gross egg yield of laying hens

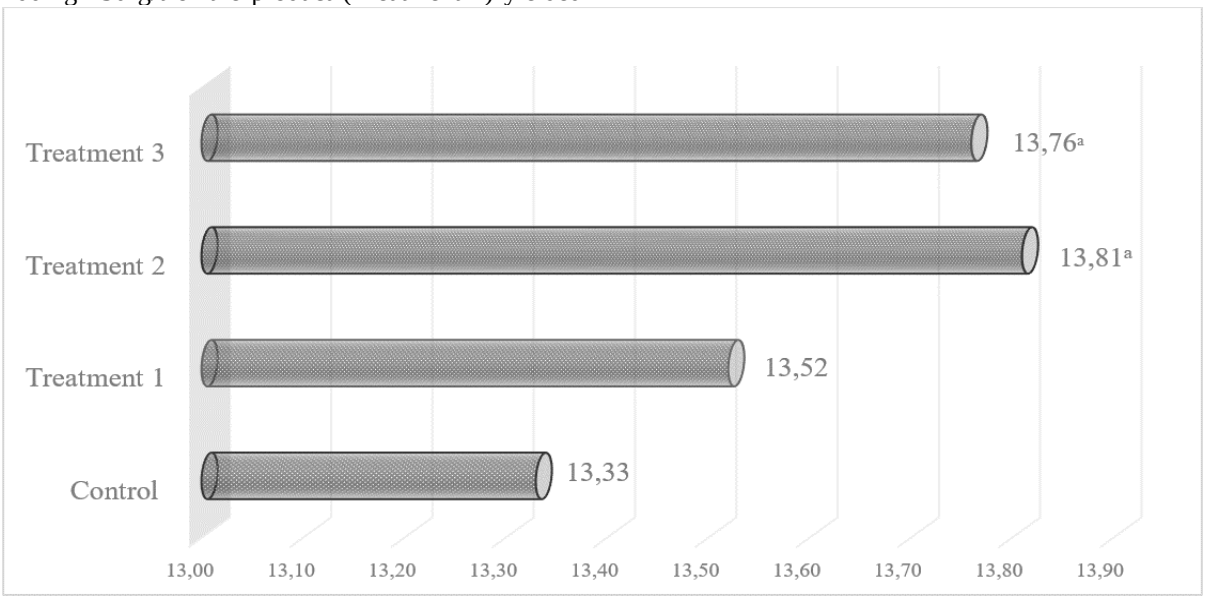
In Figure 3, we see that the weight of eggs obtained from the experimental groups consuming feed supplemented with benzoic acid and Actigen significantly differed from the control by 2.79% or 1.65 g and 4.09% or 2.42 g, respectively ($p \leq 0.001$). In our opinion, the increase in egg weight is explained by improved digestion and absorption of feed nutrients as a result of the positive effect of the studied products on the condition of the intestinal villi, which is consistent with literature data describing the modification of intestinal morphology and optimization of the microbiome when using benzoic acid and mannanoligosaccharides in poultry diets [4, 5].



c - p≤ 0.001

Figure 3. Weight of laying hens' eggs, g

A quail experiment also showed positive changes in egg weight when using Sal-Zap as a feed acidifier. Adding 750 g/t of the product (Treatment 2) yielded better results, increasing egg weight by 0.48 g or 3.60% ($p \leq 0.05$).



a - p≤ 0.05

Figure 4. Weight of quail eggs, g

Treatments have shown that acidifying compound feed for laying hens and quails has a positive effect on egg production and egg weight. The results highlight improved nutrient absorption due to modification of the intestinal microflora by lowering the pH. These findings have practical significance for producers of chicken and quail eggs.

Conclusion. Studies of various feed acidifiers and mannanoligosaccharides at various dosages revealed positive trends in improving production indicators. Using a combination of biologically active additives in laying hens' feed: concentrated benzoic acid at 750 g/t of feed, coated benzoic acid at 200 g/t, and mannanoligosaccharides at 400 g/t yields the best results. In quail feed, the complex preparation Sal-Zap is most appropriately used at a dosage of 750 g/t of feed.

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СОВРЕМЕННЫЕ ТЕХНОЛОГИИ БИОРЕМЕДИАЦИИ ПОЧВ: МНЕНИЯ И ПРЕДЛОЖЕНИЯ

Михайлов А.В.
магистрант 1 курса
Евразийского национального университета им. Л.Н. Гумилева,
Факультет естественных наук,
кафедра управление и инжиниринг в сфере охраны окружающей среды

MODERN TECHNOLOGIES OF BIOREMEDIATION OF SOILS: OPINIONS AND SUGGESTIONS

Mikhailov A.
1st year Master's student at
L.N. Gumilyov Eurasian National University,
Faculty of Natural Sciences, Department of
Environmental Management and Engineering
DOI: 10.5281/zenodo.18077262

Аннотация

Загрязнение почв тяжелыми металлами представляет значительные риски для экосистем и здоровья человека. В данном обзоре обобщаются последние достижения (2019–2025 гг.) в технологиях биоремедиации, основное внимание уделяется фиторемедиации (фитоэкстракции и фитостабилизации), микробным подходам (PGPR, грибы), а также применению биоугля (biochar) и модифицированных амендментов. Анализ подчеркивает синергетический потенциал интегрированных стратегий, сочетающих растения, микроорганизмы и биоуголь для улучшенной иммобилизации металлов и восстановления почв. Несмотря на обнадеживающие лабораторные результаты, сохраняются ключевые проблемы, включая воспроизводимость результатов в полевых условиях, долгосрочную эффективность и старение амендментов, экономическую целесообразность, утилизацию биомассы и отсутствие стандартизированных протоколов. В обзоре подчеркивается необходимость междисциплинарных усилий, стандартизации полевых испытаний, интеграции методов машинного обучения для прогнозного моделирования и проведения комплексных анализа затрат и результатов для облегчения масштабируемого и устойчивого применения этих стратегий биоремедиации.

Abstract

Soil contamination by heavy metals poses significant risks to ecosystems and human health. This review synthesizes recent advances (2019–2025) in bioremediation technologies, focusing on phytoremediation (phytoextraction and phytostabilization), microbial approaches (PGPR, fungi), and the application of biochar and modified amendments. The analysis highlights the synergistic potential of integrated strategies combining plants, microbes, and biochar for enhanced metal immobilization and soil restoration. Despite promising laboratory results, key challenges remain, including issues of reproducibility in field conditions, long-term efficacy and aging of amendments, economic viability, biomass disposal, and lack of standardized protocols. The review emphasizes the need for interdisciplinary efforts, standardized field testing, machine learning integration for predictive modeling, and comprehensive cost-benefit analyses to facilitate the scalable and sustainable application of these bioremediation strategies.

Ключевые слова: биоремедиация, тяжелые металлы, фиторемедиация, биоуголь (biochar), PGPR, восстановление почв, синергетические эффекты, устойчивое развитие, машинное обучение.

Keywords: bioremediation, heavy metals, phytoremediation, biochar, PGPR, soil restoration, synergistic effects, sustainability, machine learning.

Введение

Загрязнение почв тяжёлыми металлами (ТМ), такими как кадмий (Cd), свинец (Pb), мышьяк (As), ртуть (Hg), медь (Cu), никель (Ni) и цинк (Zn), представляет собой глобальную экологическую проблему, масштабы которой продолжают расти вследствие интенсификации процессов урбанизации, промышленной и сельскохозяйственной деятельности [2, 26]. Эти элементы, обладая свойствами устойчивости, биоаккумуляции и токсичности, не разлагаются в природной среде, а лишь мигрируют между её компонентами оставаясь подвижными. Накопление ТМ в почвах приводит к деградации агроэкосистем, снижению биоразнообразия почвенной биоты, попаданию металлов в цепи питания с последующими процессами биомагнификации и в конечном итоге, к серьёзным рискам для здоровья человека, включая онкологические, неврологические и почечные заболевания [5, 8].

Биоремедиация — совокупность биологических методов, направленных на снижение подвижности, био-доступности или концентраций металлов в почве — рассматривается как экономически и экологически обоснованный подход по сравнению с физико-химическими технологиями [1–4]. За период с 2019 по 2025 гг. литература существенно расширила знания о фиторемедиации, микробной ремедиации, применении био-ампендментов (biochar) и комбинированных подходах, а также о возможностях их предсказуемого управления с помощью методов машинного обучения [3, 4, 9, 28].

Современные направления и технологии

Фиторемедиация (phytoextraction, phytostabilization)

Фиторемедиация остаётся одним из наиболее исследованных биологических подходов: выделяют стратегии phytoextraction (удаление металлов живой биомассой) и phytostabilization (фиксирование металлов в ряду с уменьшением их био-доступности) [5, 13, 25]. Современные обзоры подчёркивают, что эффективность зависит от выбора видов-аккумуляторов, агрохимических условий и взаимодействия «растение—микробиота»; интеграция с амендментами (biochar, компосты) повышает стабильность и снижает фитотоксичность [7, 13, 25].

Микробные подходы (бактерии, грибы, PGPR)

Микробная ремедиация (бактерии, грибы, растения-ростостимулирующие микроорганизмы — PGPR) обеспечивает биотрансформацию и иммобилизацию металлов, участие в синтезе биопелл-комплексов и улучшении фитотранспорта [6, 14, 16]. Ряд исследований демонстрирует, что селективное использование PGPR и микоризных грибов повышает биомассу растений и эффективность phytoextraction при одновременном снижении фитотоксичности [6, 16, 24]. Использование микробных подходов может быть наиболее эффективным при использовании с фиторемедиантами такими как гибискус и подсолнечник обладающих повышенной эффективностью в процессах биоремедиации за счёт высокой способности к адсорбции [16].

Biochar и модифицированные амендменты

Biochar и его модификации — ключевой инструмент для иммобилизации тяжёлых металлов: он уменьшает подвижность элементов за счёт сорбции, комплексообразования и изменения pH/катионного обмена [3, 4, 10, 11]. Современные исследования фокусируются на долголетних эффектах, старении biochar и влиянии модификаций (нанокомпозиты, функционализация) на сорбционные свойства и биодоступность металлов [4, 10, 15, 29]. Мета-анализы указывают на вариабельность полевых результатов в зависимости от природы почвы и условий применения [4, 21, 26]. Эти данные говорят о том что присутствует необходимость в дальнейших исследованиях вопроса

Комбинированные технологии и усиленные биосистемы

Комбинации растений + микробов + biochar показывают синергетический эффект: biochar стабилизирует металлы и создает благоприятную среду для полезной микрофлоры, а PGPR усиливает усвоение/детоксикацию и рост растений [19, 24, 27]. Полевые и контейнерные исследования подтверждают, что интегрированные стратегии чаще обеспечивают длительную стабилизацию и улучшение почвенной функции [18, 22, 27]. Внедрение данных комбинаций в процессы биоремидиации позволяет повысить эффективность каждого из реагентов реакции, что несомненно приведёт к увеличению скорости процесса и повышению долгосрочной эффективности его результата.

Аналитика, прогнозирование и инструменты оптимизации

Последние годы отмечены интеграцией машинного обучения и моделирования для прогнозирования результатов ремедиации и подбора оптимальных сочетаний амендментов и видов растений/микроорганизмов [3, 28]. Это направление повышает воспроизводимость и помогает перенести лабораторные находки в полевые условия, стоить модели на основе множества на первый взгляд невзаимосвязанных факторов, и ускорять будущие процессы восстановления почв.

Критические замечания и современные ограничения (мнения)

1. ***Воспроизводимость и масштабирование.*** Лабораторные успехи не всегда переносимы на полевые условия из-за вариабельности почвенно-климатических факторов; необходимы долгосрочные полевые испытания и мониторинг [4, 21, 22].

2. ***Долгосрочные эффекты biochar.*** Старение biochar изменяет его свойства; результаты зависят от исходного сырья и метода пиролиза [10, 11, 21].

3. ***Биоэтические и экологические риски.*** Аккумуляция металлов в биомассе создаёт вопросы о дальнейшей судьбе растительных материалов (утилизация, сжигание) и рисках вторичной контаминации [5, 7].

4. ***Коммерческая рентабельность.*** Не всегда экономически оправдано применять комбинированные стратегии на больших площадях без чёткого анализа затрат и выгод [2, 19].

5. ***Неоднородность данных и методологий.*** Недостаток стандартизации измерений и критериев успеха осложняет мета-анализы и обобщения [13, 26].

Предложения и практические рекомендации

1. ***Разработка стандартизированных протоколов полевых испытаний*** (единичные метрики эффективности, длительность наблюдения, управление биомассой). Это позволит объединять результаты разных исследований и проводить корректные мета-анализы [13, 26].

2. ***Интеграция biochar + PGPR + фито-стратегий как исходная платформа*** для реконструкции деградированных почв: рекомендовано тестировать модифицированные biochar с целевой функционализацией для конкретных металлов (Cd, Pb, Zn). При этом учитывать специфику почвы и климата [3, 11, 15, 19].

3. ***Внедрение модельных подходов (ML)*** для предсказания результатов и минимизации числа дорогостоящих полевых тестов: использовать обученные модели на наборах, включающих характеристики почвы, металлоспецифичность и варианты амендментов [28].

4. ***План утилизации биомассы*** растений-аккумуляторов: рекомендуется разработать стандарты для безопасной утилизации (термическая обработка с контролем выбросов, извлечение металлов) [5, 7].

5. ***Оценка экономической жизнеспособности***: внедрять пилотные проекты с полным учётом

затрат/выгод и экологической отдачи, чтобы выявить сценарии, пригодные для масштабирования [2, 19].

6. ***Междисциплинарные консорциумы*** (агрономы, микробиологи, инженеры, аналитики данных) для комплексной разработки и валидации решений [24, 27].

Вывод

Современные способы биоремедиации почв подразумевают под собой широкое использование методов основанных на фиторемедиации с дополнением в виде использования PGPR и Biochar позволяют серьёзно повысить эффективность процесса за счёт синергетического воздействия компонентов. Но в данных процессах в современных литературных источниках заметен, только начальный уровень работы над данными взаимодействиями из-за малой изученности данной синергии на пути возникают различные сложности из-за старения biochar, и оценки экономической рентабельности вопроса при повсеместном применении. Так же недостаточно внимания было уделено вопросам утилизации отмершего растительного материала для предотвращения повторного загрязнения. Эти данные могут говорить о том, что необходимы дальнейшие исследования в вопросах синергетической работы данных методов биомелиорации для расширения их рентабельности и соответственно эффективности в будущем.

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CULTUROLOGY

МЕТОДЫ ВЫЯВЛЕНИЯ СПОРТИВНЫХ СПОСОБНОСТЕЙ У ДЕТЕЙ

Рагимов М.
ORCID: 0009-0008-4275-4237,
канд. пед. наук,
Нахчыванский государственный университет,
г. Нахчыван. Азербайджан
Рзаев О.
ORCID: 0009-0007-6377-255X,
Нахчыванский государственный университет,
г. Нахчыван, Азербайджан

METHODS FOR IDENTIFYING CHILDREN'S SPORTS APTITUDE

Rahimov M.
ORCID: 0009-0008-4275-4237
Ph.D., Nakhchivan State University,
Nakhchivan, Azerbaijan
Rzayev O.
ORCID: 0009-0007-6377-255X
Nakhchivan State University
Nakhchivan, Azerbaijan
DOI: 10.5281/zenodo.18077306

Аннотация

Физическое воспитание детей всегда было в центре внимания как азербайджанских, так и мировых ученых. Выдающиеся мыслители, такие как Низами Гянджеви, Мухаммед Физули, Гасан бек Зардаби, Марагали Авхади, Платон, Аристотель, Иоанн Амос Коменский, Жан-Жак Руссо, Петр Лесгафт и другие, структурировали образование и воспитание детей по возрастным группам. По мнению известного интеллектуала Гасан бека Зардаби, физическое воспитание играет решающую роль в успешной реализации интеллектуального и нравственного развития. Для улучшения этих качеств детей исторически делили на возрастные группы. К разделению детей на возрастные группы в ходе образовательного процесса разные учёные подходили по-разному. Выдающийся азербайджанский поэт и философ Марагали Авхади, говоря о физическом воспитании, предложил физические упражнения и игры, соответствующие возрастным периодам детей. Эту идею проведения физического воспитания в соответствие с возрастными особенностями следует рассматривать как значительное достижение для своего времени. В 7-8-летнем возрасте, поскольку кости еще развиваются и приближаются к строению костей взрослого человека, рекомендуются виды спорта, требующие частых прыжков и ловкости, такие как баскетбол, гандбол, прыжки в длину. Это связано с тем, что на этом этапе скелетная система претерпевает значительные изменения, и занятия такими видами деятельности помогают повысить прочность костей и общее физическое развитие. В возрастном периоде 8-12 лет продолжается развитие всех органов и систем у детей и подростков. Окостенение костей и развитие мышц ускоряются, и к 12 годам кости уже не отличаются от костей взрослого человека. На этом этапе в качестве подходящих видов спорта для детей можно рекомендовать виды спорта, требующие ловкости, гибкости, скорости реакции, внимания и психологической выносливости, такие как дзюдо, футбол, настольный теннис, бадминтон. Эти виды спорта помогают развивать физические и умственные способности, необходимые для дальнейшего роста и развития.

Abstract

The physical education of children has always been a focus of attention for both Azerbaijani and global scholars. Prominent thinkers such as Nizami Ganjavi, Mahammad Fuzuli, Hasan bay Zardabi, Maragali Avhadi, Plato, Aristotle, John Amos Comenius, Jean-Jacques Rousseau, Peter Lesgaft, and others have structured children's education and upbringing based on age groups. According to the renowned intellectual Hasan bay Zardabi, physical education plays a crucial role in successfully implementing intellectual and moral development. P.F. Lesgaft regarded physical education as one of the primary tools for shaping willpower, character, moral upbringing, intellectual ability, physical activity, and aesthetic appreciation. To improve these qualities, children have historically been divided into age groups. The division of children into age groups during the educational process has been approached differently by various scholars. The prominent Azerbaijani poet and philosopher Maragali Avhadi, when discussing physical education, proposed physical exercises and games suited to children's age periods. This idea of aligning physical education with age-specific characteristics should be regarded as a significant development for its time. At the age of 7-8, as the bones are still developing and approaching the structure of adult bones, sports that require frequent jumping and agility, such as basketball, handball, and long jump, are recommended. This is because during this stage, the skeletal system is undergoing significant changes, and engaging in such

activities helps in promoting bone strength and overall physical development. During the age period of 8-12, the development of all organs and systems in children and adolescents continues. The ossification of bones and the development of muscles accelerate, and by the page of 12, the bones no longer differ from those of an adult. In this stage, sports that require agility, flexibility, reaction time, attention, and psychological endurance, such as judo, soccer, table tennis, and badminton, can be recommended as suitable sports for children. These sports help develop physical and mental skills essential for further growth and development.

Ключевые слова: дети, физическое воспитание, спортсмены, возрастная группа, дети которые начинают.

Keywords: children, physical education, athlete, age group, swimming, acceleration, children who start.

The physical education of children has always been a focus of attention for both Azerbaijani and global scholars. Prominent thinkers such as Nizami Ganjavi, Mahammad Fuzuli, Hasan bay Zardabi, Maragali Avhadi, Plato, Aristotel, John Amos Comenius, Jean-Jacques Rousseau, Peter Lesgaft, and others have structured children's education and upbringing based on age groups. According to the renowned intellectual Hasan bay Zardabi, physical education plays a crucial role in successfully implementing intellectual and moral development. P.F. Lesgaft regarded physical education as one of the primary tools for shaping willpower, character, moral upbringing, intellectual ability, physical activity, and aesthetic appreciation. To develop these qualities, children have historically been divided into age groups. The division of children into age groups during the educational process has been approached differently by various scholars. The prominent Azerbaijani poet and philosopher Maragali Avhadi, when discussing physical education, proposed physical exercises and games suited to children's age periods. This idea of aligning physical education with age-specific characteristics should be regarded as a significant development for its time. Plato defined the following age group in nurture. At the age of 3-6 childiren should be brought up through games on state playgrounds. At the age of 12-16, they should undergo physical training in polestra schools, etc. [1]. So, Plato considered physical training for children to be most suitable primarily between the ages of 12-16. Aristotle divided the period of age into three groups, comprising seven periods: The period from birth to the age of 7. The period from 7 to 14 years old. The period from 14 to 21 years old. Nizami Ganjavi also shared this perspective. He classified children's development into three stages: the first stage from birth to seven years old, the second stage from seven to fourteen years old, and the third stage from fourteen to twenty — one years old. The Czech educator John Amos Comenius defined age groups follows: The period from birth to 6 years old. The period from 6 to 12 years old. The period from 12 to 18 years old. Jean-Jacques Rousseau defined the age groups of children as follows: The period from birth to 2 years old. The period from 2 to 12 years old. The period from 12 to 15 years old. The period from 15 years old to the age of maturity. In modern era, when involving children in various sports activities, the anatomical and physiological changes in their bodies, according to their age group, must be taken into account in a scientifically justified form. So, if we look at the growth of children at different ages, we see that the period from birth to 3 years is considered a period of rapid physical development. 3-6 years old children [77- 84%] behavioral disorders occur. Fatigue occur often [2]. From 6 to 11-12 years old, the development of all organs and systems of children and adolescents continues [3]. The rapid growth period of a child's body occurs from birth to one year and during puberty ages 11-15. In this stage, the height increases by 7-8 cm per year, and sometimes even by 10 cm [3]. The period of completion of sexual maturity of young people depends on their gender and individual characteristics: It occurs in girls at the age of 12-16, in boys at the age of 13-18. At this stage, psychological and physical development mostly ends [2]. However, this age classification has recently been demanded to change. This is because the issue of acceleration has started to manifest itself. Acceleration, derived from the Latin word acceleratio, refers to the speeding up of physical and psychological development during childhood [2]. Therefore, when involving children in sports programs, the age group from previous years should be re-evaluated. In the modern era, the development and diversification of sports, along with the significant differences in training methods for these sports, make it crucial to determine at what age a child should begin practicing a particular sport. An athlete's future level of achievement is highly dependent on the sport they choose to pursue in their childhood. Not all children know which sport is suitable for their body. Most of them choose a sport based on their parents' wishes or because their friends or peers are involved in that sport, without considering whether it aligns with their anatomical and physiological structure. Sometimes, children who start a sport this way manage to achieve high results later. However, this often happens by chance. In many cases, a child initially practices a sport by chance, but eventually either switches to a different sport or, after failing to achieve any results, becomes discouraged and completely distances themselves from sports. Many children also fail to understand that achieving high results in sports requires more than just planned and regular training under the guidance of a highly qualified coach. At the same time, the athlete's anatomical and physiological characteristics, as well as their psychological traits, must align with the sport they choose [3]. In many countries around the world, this process is carried out in different ways. For example, in some countries, children focus only on general physical preparation until the age of 15. Afterward, based on certain tests, it is recommended which specific sport the child should pursue. In some countries, children are advised to enroll in a specific sport based on their physical indicators, body measurements, and psychological condition. In such cases, the child's age and enthusiasm for the sport are not taken into account. Long-term observations have led to the conclusion that none of the methods mentioned above fully meet the requirements of the

modern era [4]. Based on our long-term observations, it can be concluded that it is advisable to scientifically organize the process of selecting a sport for children. A child's height, weight, agility, gender, age, and many other characteristics should serve as measurement units to determine which sport is most suitable for them. Proper guidance is essential for achieving great success in their future lives.

While doing so, it is crucial to take the child's desires into account and provide them with the right direction. Numerous observations of children have led to the conclusion that children aged 2-3 can perform activities such as running, catching, jumping, playing water games in shallow areas under the supervision of a teacher, and simple acrobatic movements. During this age period, children can quickly master swimming movements and various acrobatic exercises in line with their developmental level. [5]. Taking into account the above, it may be more beneficial to use the step-by-step principle in choosing a sport for children. Children should be selected not once, but several times in stages, and directed to sports training according to the above parameters. [6]. At the age of 4-5, children can engage in swimming, dynamic games, gymnastics, running over various distances, and jumping. In addition to these activities, considering their weight, anthropometric measurements, physiological development, psychological state, and enthusiasm, they can also be involved in sports requiring agility and flexibility, such as swimming, acrobatics, artistic gymnastics, and others. Children at this age who practice swimming can learn it quickly because their long bones are hollow, making their body density lower, and they expend less energy to stay afloat. Young children can achieve high results in swimming more quickly. In sports like artistic gymnastics and acrobatics, younger children tend to perform better because their joints are more flexible than those of adults. While children should focus on one of these sports, they should also continue practicing other sports for general physical preparation. It is possible that in the later stages of their development, they may find that they are more suited to a different sport [7]. At the age of 7-8, as the bones are still developing and approaching the structure of adult bones, sports that require frequent jumping and agility, such as basketball, handball, and long jump, are recommended. This is because during this stage, the skeletal system is undergoing significant changes, and engaging in such activities helps in promoting bone strength and overall physical development. During the age period of 8-12, the development of all organs and systems in children and adolescents continues. The ossification of bones and the development of muscles accelerate, and by the age of 12, the bones no longer differ from those of an adult. In this stage, sports that require agility, flexibility, reaction time, attention, and psychological endurance, such as judo, soccer, table tennis, and badminton, can be recommended as suitable sports for children. These sports help develop physical and mental skills essential for further growth and development. Since there is a difference in the physical and sexual growth of girls and boys at the age of 13-14 [8]. This difference should be taken into account in the process of involving them in various sports. Regardless of the sport chosen, it is advisable for children aged 10-12 to also engage in swimming, athletics, basketball, and gymnastics to ensure proper physical development, normal growth, and posture formation. The age of 13-14, it is not recommended for children to start sports that require special strength and endurance, as the bone development is not yet complete. Sports that place significant strain on the body may negatively affect the growth and overall development of the child's body. At the age of 13-14, it is appropriate to gradually introduce strength-developing movements. During this period, exercises that require endurance, various weight-bearing movements, bodyweight exercises, and gymnastics movements using equipment (such as pull-ups, parallel bars, and jumps on various apparatus) can be taught. Children at this age can regularly engage in sports like athletics, judo, football, freestyle wrestling, Greco-Roman wrestling, combat sports, weightlifting, and others. After the age of 15 [9]. The choice of sport can be tailored based on the child's weight, anthropometric measurements, physiological development, psychological condition, and enthusiasm. At this stage, a more precise and consistent sport regimen can be established based on these factor

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ECONOMIC SCIENCES

ЦИФРОВИЗАЦИЯ БЮДЖЕТИРОВАНИЯ: ОБЗОР МЕТОДОЛОГИЧЕСКИХ ПОДХОДОВ И МОДЕЛЕЙ

Пшембаева Д.А.
Докторант программы DBA Алматы Менеджмент Университет, MBA

DIGITALIZATION OF BUDGETING: A REVIEW OF METHODOLOGICAL APPROACHES AND MODELS

Pshembayeva D.
Doctoral student of the DBA program Almaty Management University, MBA
DOI: 10.5281/zenodo.18077326

Аннотация

Статья посвящена систематизации методологических подходов и моделей цифрового бюджетирования, представленных в современной научной и профессиональной литературе. Выполнен обзор архитектурных, процессных и аналитических моделей, определяющих направления цифровой трансформации бюджетного процесса и формирующих основу для интеграции цифровых технологий в финансовое планирование. Проанализированы ключевые преимущества цифровых решений, включая повышение точности прогнозирования, ускорение бюджетных циклов и расширение возможностей анализа данных. Рассмотрены также ограничения и методологические противоречия, влияющие на практическую применимость различных моделей, включая требования к качеству данных, цифровой зрелости и компетенциям персонала. Представленные результаты позволяют уточнить теоретические основы цифрового бюджетирования и формируют научно-методическую базу для дальнейших исследований в области цифровой трансформации финансовых функций.

Abstract

The article provides a systematic review of methodological approaches and models of digital budgeting presented in contemporary academic and professional literature. The study offers an overview of architectural, process-oriented, and analytical models that shape the digital transformation of the budgeting process and form the foundation for integrating digital technologies into financial planning. Key advantages of digital solutions are analysed, including improved forecasting accuracy, accelerated budgeting cycles, and enhanced data-driven analytical capabilities. The article also examines limitations and methodological inconsistencies that affect the practical applicability of various models, such as requirements for data quality, digital maturity, and staff competencies. The findings clarify the theoretical foundations of digital budgeting and contribute to the methodological basis for further research on the digital transformation of financial functions.

Ключевые слова: цифровизация бюджетирования, методологические подходы, архитектурные модели, процессные модели, аналитические модели, финансовое планирование, цифровая трансформация.

Keywords: digital budgeting, methodological approaches, architectural models, process models, analytical models, financial planning, digital transformation.

Введение

Цифровая трансформация финансовых функций приводит к существенным изменениям в процессах бюджетирования и финансового планирования. Традиционные подходы, основанные на последовательных процедурах формирования бюджета, ручной обработке данных и ограниченных аналитических возможностях, становятся недостаточно эффективными в условиях растущей динамичности внешней среды и усложнения управленческих задач. Переход к цифровым моделям бюджетирования позволяет повысить качество планирования, ускорить обработку данных и обеспечить более точное прогнозирование.

Несмотря на значительный интерес к проблематике цифровизации финансов, методологические основания цифрового бюджетирования в научной литературе представлены фрагментарно. Отсутствие единой классификации существующих моделей и недостаточная систематизация концепций затрудняют сравнительный анализ подходов и оценку их применимости в различных организационных контекстах. В этих условиях возрастает необходимость обзорного исследования, направленного на структурирование теоретических подходов и моделей цифрового бюджетирования, используемых в международной практике.

Цель статьи состоит в систематизации методологических подходов к цифровизации бюджетирования и анализе моделей, лежащих в основе современных цифровых финансовых систем.

Для достижения цели поставлены задачи:

– изучить теоретические подходы к трансформации процессов бюджетирования;

– систематизировать модели цифрового бюджетирования, представленные в научной и профессиональной литературе;

– определить методологические рамки анализа цифровых моделей;

– сформировать теоретическую базу для дальнейших исследований в области цифрового финансового планирования.

Статья носит обзорный характер и направлена на обобщение ключевых концепций цифрового бюджетирования, что позволяет укрепить методологическую основу дальнейших теоретических и прикладных исследований.

1. Литературный обзор

Бюджетирование традиционно рассматривается как ключевая функция финансового управления, обеспечивающая планирование, распределение ресурсов и контроль. Классические подходы, включая традиционное бюджетирование, бюджетирование «с нуля» (Zero-based Budgeting) и бюджетирование на основе видов деятельности (Activity-based Budgeting), подробно описаны в фундаментальных работах Ч. Хорнгрена и его последователей [1]. Данные модели остаются основой финансового планирования, однако в работах современных исследователей отмечается, что их статичность и высокая трудоёмкость ограничивают применимость в условиях цифровой экономики [2].

Растущее внимание уделяется трансформации бюджетного процесса под воздействием цифровых технологий. Согласно отчётам ACCA и PwC, цифровизация позволяет существенно сократить продолжительность бюджетных циклов, повысить качество данных и расширить аналитические возможности финансовой функции [3, 4]. В отчётах McKinsey подчеркивается переход от периодического бюджетирования к моделям непрерывного планирования (Continuous Planning) и скользящих прогнозов, что повышает адаптивность компаний к изменениям внешней среды [5]. Значимым направлением исследований являются модели цифрового бюджетирования, основанные на аналитике данных, автоматизации и применении алгоритмов прогнозирования. Gartner в серии исследований выделяет движение к Data-driven Budgeting и интеграции предиктивной аналитики, позволяющей формировать прогнозы на основе больших массивов операционных данных [6]. Аналогичные выводы представлены в работах IBM, где описываются когнитивные инструменты финансового планирования на базе IBM Planning Analytics, использующие алгоритмы машинного обучения для прогнозирования и сценарного анализа [7].

Процессные модели цифрового бюджетирования получили развитие в рамках методологий BPM и APQC, где бюджет рассматривается как часть сквозной цепочки управления. Такого рода подходы предполагают стандартизацию ролей, этапов и регламентов формирования бюджета, что повышает прозрачность и управляемость процесса [8]. Исследования Deloitte подчёркивают, что цифровая трансформация бюджетирования невозможна без реинжиниринга процессов и интеграции единых платформ управления данными [9]. Важный пласт литературы посвящён моделям оценки цифровой зрелости финансовой функции. Deloitte Digital Finance Maturity Model и Gartner Maturity Model определяют уровни перехода от фрагментарной автоматизации к комплексным цифровым решениям, включая интеллектуальное планирование и самообучающиеся прогнозные модели [10, 11]. Такие модели создают методологическую основу для определения готовности организаций к внедрению цифровых инструментов бюджетирования.

Практическая реализация цифровых подходов описана в исследованиях корпоративных платформ SAP BPC, Oracle EPM, Anaplan и IBM Planning Analytics, где представлены архитектурные принципы интеграции данных, автоматизации бюджетных циклов и использования предиктивной аналитики [12, 13]. Указанные решения предлагают комплексный подход к объединению процессов бюджетирования, прогнозирования и консолидации данных в единой цифровой среде.

Литературный обзор показывает, что цифровизация бюджетирования развивается в двух взаимодополняющих направлениях:

– теоретическом (формирующем методологическую основу цифровых трансформаций);

– прикладном (описывающем архитектуру, инструменты и технологии современных цифровых бюджетных систем).

Систематизация вышеуказанных подходов создаёт основу для дальнейших исследований цифровых моделей бюджетирования и оценки их практической применимости.

2. Методология

Исследование основано на обзорном и аналитическом подходе, включающем систематизацию научных публикаций, международных стандартов и профессиональных отчётов, посвящённых трансформации процессов бюджетирования. В качестве источников использованы рецензируемые статьи, фундаментальные работы по управленческому учёту, а также аналитические материалы ведущих консалтинговых и технологических компаний, представляющих модели и инструменты цифрового бюджетирования.

Отбор литературы осуществлялся по критериям релевантности теме цифровой трансформации бюджетирования, признанности источника и верифицируемости данных. На основе выбранных материалов проведены классификация подходов, сравнение моделей цифрового бюджетирования и анализ методологических рамок, используемых в международной практике.

Методология исследования не предполагает сбора первичных данных и направлена на формирование теоретико-методологической базы, необходимой для последующего анализа цифровых моделей и их практической применимости.

3. Результаты

Результатом проведённого обзорного анализа стало выявление и систематизация ключевых методологических подходов и моделей, формирующих основу цифровизации процессов бюджетирования. Полученные данные показывают, что цифровое бюджетирование представляет собой комплексное направление, объединяющее эволюцию традиционных финансовых практик, развитие аналитических

технологий и распространение интегрированных корпоративных платформ.

Первым значимым результатом анализа является выявление трёх концептуальных групп моделей цифрового бюджетирования:

– архитектурных моделей, ориентированных на структурирование информационной среды;

– процессных моделей, описывающих трансформацию этапов и регламентов бюджетирования;

– аналитических моделей, основанных на применении методов обработки данных и предиктивной аналитики.

Такая классификация позволяет рассматривать цифровизацию бюджетного процесса как многоуровневое явление, затрагивающее инфраструктуру данных, организационные процедуры и методики прогнозирования.

Архитектурные модели представляют собой цифровые структуры, обеспечивающие интеграцию данных и автоматизацию ключевых этапов финансового планирования. Согласно публикациям SAP и Oracle, современные платформы бюджетирования строятся на принципах единого источника данных, модульности, автоматизированной консолидации и сквозной аналитики [12, 13]. Модели позволяют уменьшить число ручных операций, повысить прозрачность бюджетного процесса и обеспечить непрерывную доступность актуальной финансовой информации. Анализ международных источников показывает, что архитектурные решения становятся основой цифровых экосистем, объединяющих бюджетирование, прогнозирование и стратегическое планирование.

Процессные модели цифрового бюджетирования связаны с преобразованием логики формирования бюджета. Исследования APQC и Deloitte свидетельствуют о переходе от линейных последовательных процедур к гибким процессам, в которых используются скользящие прогнозы, сценарный анализ и элементы непрерывного планирования [8, 9]. Такие модели позволяют организациям адаптировать бюджет к изменяющимся условиям, сокращать длительность циклов планирования и интегрировать управление рисками в бюджетный процесс. Результаты анализа подтверждают, что процессные модели являются ключевым инструментом повышения адаптивности и управляемости финансовой функции.

Аналитические модели цифрового бюджетирования формируются в рамках развития технологий обработки данных, прогнозной аналитики и алгоритмов машинного обучения. Gartner и IBM выделяют направление Data-driven Budgeting, предполагающее формирование бюджетов на основе больших массивов данных, автоматизированных прогнозов и интеллектуальных алгоритмов [6, 7]. Такого рода модели включают инструменты идентификации трендов, анализа вариативности, оценивания рисков и построения многомерных моделей прогнозирования. Результаты анализа показывают, что применение аналитических моделей значительно повышает точность финансовых прогнозов и позволяет организациям принимать решения на основе объективных данных.

Важным результатом исследования является выявление роли моделей цифровой зрелости, которые используются для оценки готовности организаций к внедрению цифрового бюджетирования. Модели Deloitte и Gartner содержат уровневую структуру зрелости, отражающую переход от базовой автоматизации к интегрированным цифровым платформам и интеллектуальным финансовым системам [10, 11]. Указанные модели позволяют формировать дорожные карты цифровой трансформации, определять необходимый набор инструментов и оценивать степень развития финансовой функции в динамике.

Анализ литературы также показал, что цифровые модели бюджетирования интегрируются в корпоративные платформы класса EPM, предлагающие комплексный подход к планированию, прогнозированию и консолидации данных. Решения SAP BPC, Oracle EPM и IBM Planning Analytics обеспечивают автоматизацию финансовых процессов, унификацию данных и применение аналитических методов в реальном времени [12, 13]. Их использование способствует сокращению операционных затрат, повышению точности прогнозов и усилению контроля за финансовыми потоками.

Таким образом, результаты анализа свидетельствуют о формировании целостной методологической основы цифрового бюджетирования, включающей архитектурные, процессные и аналитические модели. Цифровизация бюджетного процесса становится многоаспектным явлением, охватывающим трансформацию данных, технологий и организационных подходов. Систематизация существующих моделей позволяет уточнить содержание цифрового бюджетирования, определить направления развития финансовой функции и заложить основу для формирования практических рекомендаций по внедрению цифровых решений.

4. Обсуждение

Результаты анализа показывают, что цифровое бюджетирование формируется на пересечении технологических, организационных и методологических преобразований. Однако выявленные модели демонстрируют не только потенциал развития финансового планирования, но и ряд ограничений, противоречий и дискуссионных аспектов, требующих критической оценки.

Архитектурные модели, основанные на интеграции данных и цифровых платформ, рассматриваются в литературе как фундамент цифровой трансформации бюджетирования. Тем не менее исследования SAP и Oracle показывают, что внедрение таких моделей сопряжено с высокой степенью технологической зависимости, значительными первоначальными затратами и рисками несогласованности данных на ранних этапах цифровизации [12, 13]. Кроме того, стандартизация архитектуры может вступать в противоречие с потребностью отдельных подразделений в гибкости, что порождает конфликты между централизованными и децентра-

лизованными моделями управления. Архитектурные решения создают основу цифровизации, но требуют значительных инвестиций в инфраструктуру, управление данными и организационное взаимодействие.

Процессные модели, включающие скользящие прогнозы и элементы непрерывного планирования, расширяют адаптивность бюджетного процесса. Однако исследования APQC и Deloitte отмечают, что переход к таким моделям ограничивается степенью управленческой зрелости организации, наличием устойчивых процедур и готовностью персонала к работе в условиях высокой частоты обновления данных [8, 9]. Более того, гибкие процессные модели могут вступать в противоречие с традиционными системами контроля и испытать сопротивление со стороны руководителей, ориентированных на фиксированные бюджеты, что в свою очередь указывает на необходимость сбалансирования гибкости и формализованности, особенно в организациях с устоявшимися бюрократическими структурами.

Аналитические модели, основанные на предиктивной аналитике и алгоритмах машинного обучения, создают значительный потенциал повышения точности прогнозирования. Однако исследования Gartner и IBM подчёркивают, что качество прогнозов напрямую зависит от полноты, достоверности и структуированности данных [6, 7]. В условиях низкой цифровой зрелости аналитические инструменты могут давать искажённые результаты, усиливать существующие ошибки и повышать неопределённость. Кроме того, применение сложных алгоритмов требует развитых компетенций персонала и вызывает дискуссии в научной литературе относительно прозрачности принимаемых решений: организации нередко сталкиваются с эффектом «чёрного ящика», когда алгоритм выдает прогноз, но принципы его формирования остаются непрозрачными. Такие ограничения указывают на необходимость сочетания автоматизированных методов с экспертным суждением.

Особое внимание заслуживают модели цифровой зрелости, которые рассматриваются как инструмент оценки готовности компаний к внедрению цифровых технологий. Однако исследования Deloitte и Gartner отмечают, что универсальные модели зрелости не всегда корректно отражают специфику отраслей, региональных рынков и корпоративных культур [10, 11]. Проблема состоит в том, что такие модели часто формируются как обобщённые фреймворки, ориентированные на крупные международные корпорации, что снижает их применимость в контексте развивающихся рынков и компаний среднего размера. Следовательно, оценка цифровой зрелости требует адаптации методик и индивидуализации дорожных карт трансформации.

Интеграция цифровых моделей в платформы EPM демонстрирует значительный эффект в части автоматизации и повышения точности бюджетирования. Однако исследования SAP, Oracle и IBM подчёркивают, что широкое внедрение таких платформ приводит к зависимости организации от экосистемы поставщика, необходимости постоянного обновления решений и высоких издержек на сопровождение [12, 13]. Кроме того, платформенные решения нередко стандартизируют процессы, что ограничивает пространство для управленческих инноваций и снижает организационную гибкость. Цифровизация не является универсальным решением и требует взвешенного выбора инструментов в соответствии с контекстом организации.

Исходя из результатов проведенного анализа, делается вывод о том, что, цифровизация бюджетирования является комплексным и неоднозначным процессом, включающим технологические преимущества и методологические риски. Архитектурные, процессные и аналитические модели представляют значительный потенциал повышения качества финансового планирования, однако их успешное внедрение зависит от состояния данных, компетенций персонала, уровня цифровой зрелости и организационной структуры. Не все компании готовы к полному переходу к цифровому бюджетированию, и в некоторых случаях смешанные, гибридные модели могут быть более устойчивыми. Цифровизация бюджетирования требует не только выбора технологий, но и критического переосмысления подходов к планированию, управлению данными и организации финансовой функции. Обсуждение подтверждает взаимозависимость моделей цифрового бюджетирования и подчёркивает необходимость комплексного подхода, учитывающего как потенциал, так и ограничения цифровых решений.

Заключение

Проведённый обзор методологических подходов и моделей цифрового бюджетирования показал, что цифровая трансформация финансового планирования представляет собой комплексный процесс, включающий изменения в архитектуре данных, организационных процедурах и аналитических инструментах. Современные архитектурные, процессные и аналитические модели образуют основу цифровых бюджетных систем, обеспечивая более высокую точность прогнозирования, сокращение длительности бюджетных циклов и повышение адаптивности организации.

В то же время выявленные ограничения и методологические противоречия свидетельствуют, что успешная цифровизация бюджетирования требует развитой инфраструктуры данных, компетентного персонала и зрелых управленческих процессов. Универсальных решений не существует, и выбор модели цифрового бюджетирования должен учитывать специфику организации, её цифровую зрелость и стратегические приоритеты.

Полученные результаты формируют теоретико-методологическую основу для дальнейших исследований, направленных на оценку эффективности цифровых инструментов, анализ практик внедрения и разработку адаптированных моделей бюджетирования для различных типов предприятий.

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HISTORICAL AND ARCHEOLOGICAL SCIENCES

THE KIPCHAK MIGRATION TO THE CAUCASUS

Seyidova S.
Prof. Dr.
Azerbaijan State Pedagogical University
ORCID: 0009-0003-8839-3506
DOI: 10.5281/zenodo.18081730

Abstract

Nomadic tribes of Turkic origin, known as Kipchaks, left a deep mark in the history of the steppe regions of Eurasia, and had a serious impact on the development of Eastern European states. The Kipchaks participated in the ethnogenesis of most of the current Turkic peoples, including the Azerbaijani Turkic.

Turkic tribes of Kipchaks also actively participated in the formation of a number of nations. Among the numerous Turkic peoples, in the formation of which the Kipchaks participated, it is possible to mention the Kazakhs, Kyrgyz, Karakalpak, Turkmen, Tatars, Bashkir, Altais and other peoples of the Northern Caucasus (Nogay, Karachay, Balkar). This also testifies to the great role of the Kipchaks in the formation of these nations. Kipchak ethnic elements were also included in the composition of Ottoman Turkic, Azerbaijanis, Hungarians and other nations.

Keywords: The Turkic tribes, Kipchak, Origin, Migration, Caucasus, Russia, Eurasian steppes.

İntroduction

Kipchaks are Turkic nomadic tribes that played a significant role in the history of the Eurasian steppes. Starting from the 9th-10th centuries, they gradually occupied vast territories from the Irtysh and Altai to the Black Sea, forming a powerful military-political union, known in Russian and Eastern sources as the Polovtsy, and in Western European sources as the Kumans. Their mobile nomadic way of life, developed military organization and active participation in trade made the Kipchaks one of the key peoples of the steppe world of the Middle Ages. Interacting with Russia, Byzantium, Khorezm and other states of the region, they had a significant impact on the political processes and cultural exchange of that time. The history of the Kipchaks became an important part of the formation of the ethnic map of modern Turkic peoples, including Kazakh, Karachay, Balkars and others.

1. Questions about Origin

The word "Kipchak" is first mentioned in the work of the Chinese historian Sima Qian, "Historical Notes." In this work, he mentions the names of five tribes that were part of the Asian Huns: Hongyu, Xuyishe, Dinglin, Tsegun, and Saily (Xinli) (3rd century BC – the era of the Xiongnu ruler Modu). The Kueyishe tribe, conquered by Modu, lived in the northwestern part of the Altai. The term "Kueyishe" or "Xuyishe," first mentioned in 201 BC, is accepted by Turkologists as the first name for the Kipchaks in written sources [1, pp. 199-216]. According to many historical sources, the Kipchaks settled in the Zheliang Valley in ancient times. The name of this valley coincided with the name of the Chilyan River, which means Snake River and Snake Mountain. G.E. Grumm-Grzhimailo associated the name of the city of Zmeinogorsk with these toponyms [4, p. 59]. In the 3rd-2nd centuries BC, the Kipchaks lived in the northwestern regions of Altai. According to N.A. Aristov, in the 1st century BC and 1st century AD, individual groups of Kipchaks could have migrated from the upper reaches of the Irtysh and from areas west of Tarbagatai [2, pp. 283-290, 309, 312-313]. From the 3rd century BC, the Kipchaks, like other Altai tribes, were part of the Huns. From the 2nd century to the 4th centuries AD, the Kipchaks were under the political domination of the Xianbei tribes, and from the end of the 4th century. to the first half of the 6th century — under the political domination of the Mongol-speaking Juan Juan tribes [15, p. 19]. The Juan Juan constantly oppressed the Turkic tribes, which is why in 552 the Turkic tribes united and put an end to the Juan Juan rule. The head of the new state - the Turkic Khaganate - became Tumen (Bumyn), who took the title of Ilkhan, and in 555 the Turkic finally destroyed the Juan Juan state. Later, this title was replaced by the title of Khagan. Many Sayan-Altai tribes were included in this Khaganate. As inhabitants of Altai, the Kipchaks were also part of the Turkic Khaganate, but did not have any power in the Khaganate. For this reason, there was no information about them in ancient sources until the middle of the 7th century [15, pp. 17-19]. The Kipchaks are also mentioned in tombstone inscriptions dating back to 759–760, discovered by Gustav Ramstedt in 1909 near the Selenga River in south-central Mongolia. In literature, this epitaph was called the "Selegin Stone." This inscription is a text from a tombstone that belonged to one of the founders of the Uyghur Khaganate, Eletmish Bilge Khagan (747–759) [14, p. 134]. On the north side of the stone, in the fourth line, the following words are carved: "When the Turkic Kipchaks ruled us for fifty years..." [14, p. 145]. The renowned Arab geographer Ibn Khordadbeh (9th century, "Kitab al-masalik wa-l-mamalik" - Book of Routes and Countries) was the first explorer to identify the Kipchaks as a Turkic tribe. He presented the Kipchaks as an independent tribe living in the territory of modern-day Kazakhstan [5, pp. 64-65, 184-185].

The earliest written sources that left us with information about the Kipchaks include Arabic and Persian sources, which provide comprehensive and informative information on the history of the emergence of the Turkic ethnic group, including the Kipchaks. Among these works, the works of Arab and Persian geographers of

the 9th-13th centuries occupy a special place. Authors such as the Arab geographers Al-Masudi (10th century), Al-Istakhri (10th century), and Kitab al-masalik wa-l-mamalik (Book of Routes and Countries) wrote about the Kipchaks.

Also worth noting are such scholars as G.E. Grum-Grzhimailo, V.V. Bartold, V.F. Minorsky, N.Yu. Bichurin, S.G. Klyashtorny, S.N. Gumilev, M.I. Artamonov, N.F. Kotlyar, S.A. Pletneva, N.E. Kuzembaev, A.N. Yuzeev, A.N. Garkavets, V.V. Petrukhin, N.A. Aristov, G. Geybullaev, Z. Papasciri, M.D. Lordkipanidze, I.A. Javakhishvili, F.M. Kırzıoğlu, Fuad Koprulu, Zeki Velidi Togan, and others who dedicated their works to the history of the Kipchaks.

The renowned orientalist V.V. Radlov, in his work "An Attempt at a Dictionary of Turkic Dialects," explained the following meanings of the term Kipchak.

1. The meaning of the word "Kipchak" is unclear, as it is always used with the adjective "koby" (empty). Perhaps these words have the same meaning.

2. Kipchak is an empty tree; in those days, an empty tree was called "chypchak."

3. Kipchak is an angry, crazy person [10, p. 844].

O. Suleimenov put forward the hypothesis that the ethnonym Kipchak was formed from the words "iki pchak" (eki pshak- two knives), meaning two knives. He suggests that the two horizontal lines of the tamga among the Kipchaks were once called “iki pchak” (ek pshak- two knives), and later this word, in the process of merging, turned into “Kipchak” [17, p. 146].

The vast pastures located on the shores of the Black Sea and the Sea of Azov - from the Volga to the Danube - have attracted eastern nomads since ancient times. These were successively occupied by nomadic tribal groups of the Huns (IV century), Avar and Bulgar (VI century), Khazar (VII century), Uz, Pecheneg, Turkic (IX-X centuries), Kipchaks (XI century) and Mongols (20-30s of the XIII century).

In the middle of the XI century, the Kipchaks, who had established themselves in the basins of the Volga and Don rivers, moved westward to the Dnieper steppes. Here lived the Torks (Turkic), who were the former enemies of the Kipchaks. The Torks put up strong resistance to the Kipchaks.

The advance of the Turkic’s into the Dnieper steppes was not in the interests of the Kiev state. Princes Izyoslav, Svyatoslav, Vsevolod and Vseslav marched against them in 1060. Under the pressure of the Russian army, the Turkic were forced to leave the Dnieper steppes and entered the northern borders of the Byzantine Empire [7,p.214]. But some parts of the Turkic remained under the rule of the Kipchaks around the Dnieper River. With the weakening of the Turkic and their abandonment of their territories, there was no peace in the border regions of the Russian state. Other nomads, the Kipchaks, came to replace the Turkic. By the end of the 11th century, the Kipchaks had conquered vast territories of the southern Russian steppes up to the Dniester.

In the North Caucasus, there were many pastures for year-round cattle breeding. In order to conquer these lands, the Kipchak aristocrats intensified their campaigns westward in the middle of the 11th century. Most importantly, the Kipchaks sought to conquer the Don and Black Sea steppes. The conquest of these territories provided the Kipchaks with the opportunity to control the water trade routes (Volga-Don-Dnieper) leading to the Black Sea and from there to Byzantium. The Byzantine Empire was unable to prevent the Kipchaks from advancing westward during this period, as Byzantium was embroiled in internal wars. In addition, the Byzantines were concerned about the Seljuk’s movements in Asia Minor.

The vast pastures along the shores of the Black and Azov Seas - from the Volga to the Danube - have attracted eastern nomads since ancient times. They were successively occupied by the nomadic tribes of the Huns (4th century), Avars and Bulgars (6th century), Khazars (7th century), Uzes, Pechenegs, Turkic (9th-10th centuries), Kipchaks (11th century), and Mongols (1220s-1230s).

2. Kipchaks in the Caucasus

In the middlle11th century, the Kipchaks, who had settled in the Volga and Don basins, moved westward into the Dnieper steppes. This was inhabited by the torks (Turkic), former enemies of the Kipchaks. The Torks offered fierce resistance to the Kipchaks. The advance of the Torks into the Dnieper steppes did not serve the interests of the Kievan state. In 1060, the princes Izyaslav, Svyatoslav, Vsevolod, and Vseslav rebelled against them. Under pressure from the Russian army, the Turkic were forced to abandon the Dnieper steppes and enter the northern borders of the Byzantine Empire [7,p.214]. However, some Turkic remained under Kipchak rule in the Dnieper region. With the weakening of the Turkic and their abandonment of their territories, there was no peace in the border regions of the Russian state. The Turkic were replaced by other nomads – the Kipchaks. By the end of the 11th century, the Kipchaks had conquered vast territories of the southern Russian steppes, reaching as far as the Dniester.

The North Caucasus offered abundant pastures for year-round livestock raising. To conquer these lands, the Kipchak aristocracy intensified its campaigns westward in the middle 11th century. The Kipchaks primarily sought to conquer the Don and Black Sea steppes. The conquest of these territories gave the Kipchaks control over the water trade routes (Volga-Don-Dnieper) leading to the Black Sea and from there to Byzantium. The Byzantine Empire was unable to prevent the Kipchaks' westward advance during this period, as Byzantium was engulfed in internal wars. Furthermore, the Byzantines were concerned about Seljuk movements in Asia Minor.

K.V. Kudryashov established that at the end of the 11th-12th centuries, the Kipchak-Poloves occupied the territories located around the Black Sea and on the shores of the Sea of Azov [8,p.123]. The Kipchaks also migrated to the steppes of the Fore Caucasus and the banks of the Lower Volga and Yaik rivers. The northern part of the Kipchak lands adjoined the southeastern steppes of the Kiev state. This northern part, starting from the mouth of the Danube, covered the lower reaches of the Dniester and Southern Bug rivers, the lower reaches of the Vistula, the Tyasmin River, and the Chnu River. The eastern part of the Polovtsian lands

adjoined the southern borders of the Kama Bulgars. These territories reached the Caspian Sea[8,p.146].

One group of the Kipchaks lived near the lower Volga. Their habitation in the southern Russian steppes is also evidenced by numerous burial mounds found by archaeologists in the territories from the Dniester to the Volga[9,p.172]. A certain part of the Kipchaks also lived in the North Caucasus in the 11th-13th centuries. They arrived here approximately in the 60s-70s of the 11th century.

The main areas of Kipchak migrations in the North Caucasus were considered its central part. Their capital was the city of Sunzhe, located on the banks of the Sunzha River. Archaeological data also confirm the habitation of the Kipchaks in these territories in the 11th-13th centuries. The southern border of the Kipchaks' distribution areas in the North Caucasus passed along the Armavir-Pyatigorsk-Kalmyk steppes. The Kipchaks also lived in the coastal areas of Dagestan.

There are many sources about the settlement of the Turkic tribes in Azerbaijan and in Western Asia as a whole in the 14th-15th centuries. This was shown most accurately by the author of the work "The Book of Knowledge of the World" John de Galonifontibus (1404) during his journey to the Caucasus [6, http://apsnyteka.org/809galonifontibus_ioann_de_kniga_poznaniya_mira.html]. In the chapter entitled "Tats and Goths. Great Tartary: Kumania, Khazaria and others. Peoples of the Caucasus" he wrote about the composition, religion and spread of the Turkic language among the Caucasian peoples: "In this country there are many Christians, namely: Greeks, Ziks, Goths, Tats, Volyaks, Russians, Circassians, Leks, Yasses, Alans, Avars, Kazikumukhs and almost all of them speak the Tatar language." The term "Tatar language" denoted a Turkic lang"age.

The Volyaks (Valani in German, Comani in Latin, Polovtsy in Russian;"their real name was Kipchaks) lived in the North Caucasus [6, http://apsnyteka.org/809galonifontibus_ioann_de_kniga_poznaniya_mira.html].

In the early 11th-13th centuries, separate groups of Kipchaks also lived in Azerbaijan. They were initially brought here as slaves and captives. The presence of Kipchaks in Azerbaijan is evidenced by the existence of the village of Kipchak in the Gakh region, which is associated with the name of these tribes, and the Kipchak Pass in the Kelbajar region [3, pp. 41-45].

Z. M. Buniyatov believed that the Kipchaks invaded Albania as early as the 7th century [13, pp. 123-124].

Some toponyms in Azerbaijan, such as Kazakh, Kazakhlu, and Kazakhlar, are associated with the Kipchaks. G. A. Geybullaev believed that the Kipchak origin of the Kazakhs is also confirmed by the oikonym Kaymakly (Kazakh region), which reflects the ethnonym kaymak/kimak [3, pp. 41-46]. There are many Kipchak ethnonyms in the Kakh region. One of the Kipchak ethnonyms was "Terter". According to G. A. Geybullaev, this ethnonym arose in Azerbaijan before the Kipchaks appeared in the southern Russian steppes, which suggests that some of them stayed among the Huns [3, pp. 41-45]. Also in the toponymy of Azerbaijan, one can find "Tug" (Karabakh) and Tugchay (Absheron region). The toponyms uran, andja or inji, jujan, urus or arus, kuch, durt or turut, kul, katan (kotan), and karaberk left their mark on the toponymy of Azerbaijan. G. Geybullayev believed that the Kipchaks penetrated Azerbaijan during different historical periods, approximately from the 7th to the 12th centuries [3, pp. 41-45]. Therefore, the Kipchaks played a certain role in the ethnic process that led to the formation of the Azerbaijani people [3, pp. 41-45].

Many words in the Azerbaijani language also originate from Turkic-Kipchak words. Taking this into account, linguist M.Sh. Shiraliyev writes: "As is known, beginning in the 5th century, individual Turkic languages of the Kipchak type were present in the northern part of Azerbaijan, which played an important role in the formation of the Azerbaijani vernacular." In the northern and, to some extent, eastern group of dialects and subdialects of the Azerbaijani language, Kipchak features are still clearly evident. The task of Azerbaijani dialectologists is to identify the Kipchak elements preserved in the phonetics, vocabulary, and grammar of the Azerbaijani language" [12, p. 6].

Shamseddin Eldaniz, the founder of the Eldaniz dynasty in Azerbaijan, was also of Kipchak origin. Eldaniz served in the Seljuk army, which was made up of slaves. He attracted the attention of the Seljuk nobles with his bravery and began to serve under Masud Khan. In 1143, Eldaniz was given the territory of Iran and Azerbaijan. After 40 years, the Seljuk dynasty in Iran was destroyed. Eldaniz's son Jahan Pahlavan and his grandson Uzbek preserved these lands. The Eldaniz dynasty existed in Azerbaijan until 1225, and their capital was Tabriz.

An unknown Georgian historian, in his work describing the reign of David IV (1089-1125), called these Kipchaks "Derbend Kipchaks"[1,p.125]. Georgian sources also report Kipchaks in Transcaucasia from 456 to 510, but the mass migration occurred in connection with the events of the 12th century. In 1118-1120, David IV the Builder resettled 225,000 North Caucasian Kipchaks to Georgia, led by their leader Khan Atrak, married his daughter, and, with the help of the Kipchaks, created a strong army. Later, George III (1151-1184) resettled approximately 10,000 Kipchaks to Georgia [16, pp. 236-237].

The Georgian king David IV sent an envoy to the daughter of the Kipchak Khan Atrak. Georgian sources called Atrak Khan's daughter Qurandokta (originally Turandokt). This means "Turanli daughter", "Turan daughter". David IV recruited 40 thousand selected warriors from the Kipchaks for his army and 5 thousand warriors for his personal guard. Relying on this strength, David IV broke the resistance of the Georgian feudal lords and switched from defense to attack in his foreign policy. Thus, in 1120, he crushed the Turkic-speaking nomadic tribes under the rule of the Seljuk sultans who had entered the southern and southeastern provinces of Georgia. The resettlement of Kipchaks to Georgia continued in subsequent periods.

During the reign of George III (1151-1184), tens of thousands of Kipchaks and Ossetians were also resettled here. It should be noted that during the reign of Tamara (1184-1213), the term "new Kipchaks" existed

in Georgia, which referred to newly resettled Kipchaks. The old Kipchaks were called “nakipchakara.” [1,p.119].

Conclusion

In summary, the following can be said about the Kipchaks:

1. When studying the ethnic history of the Kipchaks, we see that they are connected to various tribes. The Kipchaks had ties with the Turkic tribes of the Kimaks, Kangly, Oghuz, and others. 2. The Turkic tribes of the Kipchaks also actively participated in the formation of a number of peoples. Among the numerous Turkic peoples in whose formation the Kipchaks contributed, we can mention the Kazakhs, Kyrgyz, Karakalpaks, Turkmens, Tatars, Bashkirs, Altai, and also the peoples of the North Caucasus (Nogais, Karachays, Balkars). 3. Kipchak ethnic elements also became part of the Ottoman Turkic, Azerbaijanis, Hungarians, and other peoples.

The historical role of the Kipchaks in the development of the Eurasian steppes is determined by their long-term political dominance and significant contribution to the transformation of the region’s sociocultural space. As one of the largest Turkic confederative associations of the 11^{th}–13^{th} centuries, the Kipchaks were a key factor in interstate relations, influencing the dynamics of political processes in Eastern Europe, the Caucasus, and Central Asia. Their social structure, military-administrative organization, and adaptation to the nomadic environment ensured the stability of the Kipchak world and its ability to integrate ethnically diverse groups.

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MEDICAL SCIENCES

COMPARING THE EFFECTIVENESS OF ORAL VERSUS INTRAMUSCULAR VITAMIN D SUPPLEMENTATION IN ADULTS WITH FRACTURE AROUND HIP AND VITAMIN D DEFICIENCY

Shkiryak A.
CEO and chief medical officer "Shkiryak Clinic"
Ukraine
Neurosurgeon
MD, MsSc
ORCID: https://orcid.org/0000-0002-2282-8285
Khanenko S.
"Shkiryak Clinic"
Ukraine
Family doctor
MD, MBA
ORCID: https://orcid.org/0009-0000-4237-1158
DOI: 10.5281/zenodo.18081735

Abstract

Introduction: Cholecalciferol plays vital role in bone mineralisation. Major circulating and storage form of vitamin D is 25- hydroxycholecalciferol {25(OH)D3} which is formed in the liver after 25-hydroxylation. It is also the form of vitamin D that is measured in blood tests to detect deficiency of vitamin D. There is scarcity of literature to support the best therapy at the lowest effective dose that is practicable, cost efficient and devoid of probable side effects. Oral medication compliance is a major stumbling block to replenishing vitamin D levels in the body. Vitamin D administered intramuscularly (i.m.) may be able to overcome this limitation.

Aim: To compare the effectiveness of oral versus intramuscular vitamin D in adults with fracture around hip and vitamin D deficiency.

Materials and Methods: This prospective interventional study was conducted in Orthopaedics Ward in Mahatma Gandhi Institute of Medical Sciences, Jaipur, Rajasthan, India, from January 2020 to June 2021. Total 60 male and female, above 18 years, with fractures around the hip and vitamin D levels less 30 ng/mL were included in the study. In group O (n=30) patient received oral vitamin D supplementation of 60000 IU once a week for six weeks. In group I (n=30) patient received single dose of 600000 IU vitamin D injection (i.m.). Follow-up of patients was done at baseline, six weeks and 12 weeeks for serum values of vitamin D, calcium, alkaline phosphatase and parathyroid hormone levels. Bivariate analytical techniques has been used to measure the improvement of group I with group O.

Results: The mean age in group I was 60.40±16.38 years and in group O was 59.47±15.17 years (p-value=0.82). There were total 31 females, 13 in group I and 18 in group O. No significant difference was observed among the groups in vitamin D level at the baseline, {group I: 13.84±3.54 ng/mL; group O: 16.45±6.3 ng/mL, p-value=0.053}. At six weeks, the mean value of the vitamin D significantly increased in both groups (p-value=0.001; group I: 40.94±4.67 ng/mL and group O: 33.64±9.89 ng/mL). At the 12th week, the mean value of the vitamin D was significantly higher in group I (44.52±7.09 ng/mL) compared to group O (24.65±10.92 ng/mL), p-value <0.001. The vitamin D mean was significantly raised with the time in group I and group O at six weeks and still remained increased at 12 weeks in group I but not in group O.

Conclusion: The present study concluded that although both administration routes are effective and appear to be safe, intramuscular application is more effective in increasing 25(OH)D levels and sustaining it for a longer period of time as compared to oral dose.

Keywords: Vitamin D, cholecalciferol, effective dose, osteoporosis, oral supplementation, intramuscular injection.

INTRODUCTION

Vitamin D plays a very significant role in bone metabolism and mineralisation. It is a fat soluble vitamin, leads to its effects by acting on vitamin D receptors [1]. Lesser mineralisation of bones leads to rickets and osteomalacia [2]. It has a preventive role in various diseases like in cancer, infection, autoimmune illness, cardiovascular diseases and diabetes mellitus, among other non skeletal disorders [3].

The high prevalence of hypovitaminosis D among pregnant women and children is a major concern. Weather changes has also reflected changes in vitamin D levels [4]. In large cities, air pollution probably also plays a role [5]. Urban subjects are found to be more deficient in vitamin D [6]. One-fifth of them also have indications of parathyroid hyperactivity, as measured by Parathyroid Hormone (PTH) levels in the blood [7]. Their hypovitaminosis D is caused by a lack of sunlight exposure and skin pigmentation [8]. There are studies which have shown decreased levels of vitamin D in neonates, healthy school girls, hospital staff and pregnant women in North India [5,8-10].

In most of the studies, the criteria used for defining hypovitaminosis (vitamin D deficiency) is serum

25(OH)D level below 50 nmol/L [9-11]. Various vitamin D deficiency and insufficiency diseases have been highlighted [12]. In adults, this can lead to decreased mineralisation that is osteomalacia. Decreased levels also leads to increased incidences of hip fractures muscle weakness thus affecting the mobility and functional ability of the person [13,14]. Prevention of such eventualities is feasible by adequate sunlight exposure, food fortification and supplementation of vitamin D for at risk population as a cost-effective measure in prevention of hip and other geriatric fractures. There is need for optimising vitamin D levels in cases of osteoporosis patients given antiresorptives (bisphosphonate) and anabolic (teriparatide) drugs [15]. Active vitamin D works in tandem with two additional hormones to maintain calcium and phosphate homeostasis and PTH [16].

Physicians in India are currently prescribing a 1500 mg cholecalciferol sachet to be taken once a week for one to eight weeks for overt or occult vitamin D insufficiency [17].

Its short-term and long-term effects on serum 25(OH)D levels in Asian Indians, however, have not been well investigated. There is a scarcity of scientific literature to support the best therapy at the lowest effective dose, that is practicable, cost-efficient and devoid of probable side effects. Persistence is very low with oral vitamin D supplementation [18]. Oral medication compliance is a major stumbling block to replenishing vitamin D levels in the body. Vitamin D administered intramuscularly (i.m.) may be able to overcome this limitation. Vitamin D i.m. injections are regularly available in the market in two values (3 lac and 6 lac IU). Parenteral route (intramuscular) of administration of vitamin D has lead to effective increase in vitamin D levels but this cannot be administered without monitoring serum levels [19].

Supplementation, either oral or intramuscular, is a more realistic and easier way to receive enough vitamin D. However, no study comparing intramuscular injection and oral vitamin D dosage in Indian people has been conducted. Hence, present study was conducted to evaluate the efficacy and tolerability of oral cholecalciferol (60,000 IU) versus i.m. cholecalciferol (600,000 IU) in correcting vitamin D deficiency with fracture around hip.

MATERIALS AND METHODS

This prospective interventional study was conducted among patients, admitted to Orthopaedics Ward in Mahatma Gandhi Institute of Medical Sciences, Jaipur, Rajasthan, India, from January 2020 to June 2021. The study was permitted by Institutional Ethics Committee (MGMCH/IEC/JPR/2020/100).

inclusion criteria: All males and females above 18 years of age, with hip fractures and vitamin D levels less than 30 ng/mL were included in the study [2].

exclusion criteria: The patients taking Hormone Replacement Therapy (HRT) or anticonvulsants, with chronic debilitating illness {Chronic Obstructive Pulmonary Disease (COPD), cancer, Acquired Immune Deficiency Syndrome (AIDS), Congestive Heart Failure (CHF)}, renal disease (creatinine level >1.5 mg/dL), liver disease (bilirubin >2 mg/dL), malabsorption syndrome and patients with gastrectomy/steroid dependency were excluded from the study.

Sample size calculation: For sample size calculation, power was taken as 80%, from similar previous study by Gupta N et al., where they have used 40 samples, 20 in each arms with power 80% and level of significance 5% [20]. In present study, 10 more samples in each group 30 (total n=60) were taken.

A total 60 patients were divided equally into two groups (30 patients each group). Randomisation was done by chit in box method.

- Group O (n=30): Received oral vitamin D supplementation of 60,000 IU once a week for six weeks.
- Group i (n=30): Received i.m. vitamin D supplementation with a single dose of 6,00,000 IU vitamin D injection.

Study Procedure

A 10 mL of fasting blood samples were collected for measurement of serum vitamin D, serum calcium (albumin-adjusted) and serum PTH, Alkaline Phosphatase (ALP) levels.

1. Serum 25(OH)D level was determined by radioimmunoassay method [19].

• Vitamin D deficiency: <10 ng/mL
• Insufficiency: 10-29 ng/mL
• Optimal: ≥30 ng/mL

2. Serum PTH was determined by chemiluminescence method. Reference range for serum PTH, 1.1-6.8 pmol/L

3. Serum calcium was measured with the enzymatic method using automated spectrophotometer the reference range for serum calcium is 2.20-2.60 mmol/L [21].

Follow-up was done for oral vitamin D, intramuscular vitamin D, PTH level and calcium at baseline, at six weeks and at 12 weeks.

STATISTICAL ANALYSYS

Continuous data were summarised in the form of mean and their standard deviation. Difference in change in means of two groups were analysed using student's t-test (difference in differential analysis). Intragroup analysis of means at multiple time duration was analysed using Analysis of Variance (ANOVA). Count data were expressed in form of proportions. Difference among proportions were analysed using Chi-square test. The level of significance was kept 95% for all statistical analysis. Statistical Package for Social Sciences (SPSS) software version 14.0 (Inc.,Chicago, IL, USA) was used for all analytics works.

RESULTS

The groups were comparable according to age and sex demographics. Mean age in group I was 60.40±16.38 years and in group O was 59.47±15.17 years (p-value=0.82). There were total 31 females, 13 in group I and 18 in group O [Table/Fig-1]. In present study, 52 (86.67%) were found to be vitamin D deficient and 8 (13.33%) were vitamin D insufficient.

Variable	Group I (n=30) n (%)	Group O (n=30) n (%)	Total (N=60) n (%)	p-value*
Gender				
Male	17 (56.67%)	12 (40%)	29 (48.33%)	0.301
Female	13 (43.33%)	18 (60%)	31 (51.67%)	
Age (in years)	60.40±16.38	59.47±15.17	59.93±15.66	0.82

[Table/Fig-1]: Age and gender wise distribution across the study groups.
*Chi-square test for categorical variable; two sample independent t-test for continuous variable

At baseline, no significant difference was observed between the groups for vitamin D (p-value=0.053). At sixth week, the mean value of the vitamin D increased in both groups. Mean value was significantly higher in group I (40.94±4.67 ng/mL) as compared to group O (33.64±9.89 ng/mL) (p-value=0.001). At 12th week, the mean value of the vitamin D was significantly higher in group I (44.52±7.09 ng/mL) as compared to group O (24.65±10.92 ng/mL) with p-value <0.001 [Table/Fig-2].

Vitamin D	Group I (Mean±SD)	Group O (Mean±SD)	p-value*
At baseline	13.84±3.54	16.45±6.3	0.053
6th week	40.94±4.67	33.64±9.89	0.001
12th week	44.52±7.09	24.65±10.92	<0.001

[Table/Fig-2]: Difference in vitamin D (ng/mL) values over time between two groups.
*Two sample independent test

Statistically no significant difference was observed in the calcium level at baseline, sixth week and 12th week during follow-up between the groups as shown in [Table/Fig-3].

The [Table/Fig-4] shows the difference in ALP values over time between two groups. Baseline values in the two groups were comparable. At sixth week, the mean value of the ALP decreased from the baseline in both the group I and group O. No significant difference was observed between the groups at 6th week (p-value=0.506) and 12th weeks (p-value=0.495).

Calcium levels (mg/dL)	Group I (Mean±SD)	Group O (Mean±SD)	p-value*
At baseline	9.11±0.87	9.34±0.75	0.271
6th week	9.03±0.69	9.02±0.55	0.957
12th week	9.43±0.37	9.31±0.47	0.279

[Table/Fig-3]: Difference in calcium levels (mg/dL) over time between two groups.
*Two sample independent test is used

Alkaline phosphatase (mg/dL)	Group I (Mean±SD)	Group O (Mean±SD)	p-value*
At baseline	181.30±53.80	171.63±40.96	0.437
6th week	162.75±37.93	169.60±41.33	0.506
12th week	151.97±36.63	158.40±35.90	0.495

[Table/Fig-4]: Difference in ALP values over time between two groups.
*Two sample independent test is used

The [Table/Fig-5] depicts the difference in PTH values over time between two groups. No Significant changes were observed in the serum PTH levels at baseline (p-value=0.170). At sixth week, the mean value of the PTH decreased from the baseline in both the group I and group O. No significant difference was observed between the groups at 6th week (p-value=0.801) and 12th week (p-value=0.371).

Parathyroid hormone (mg/dL)	Group I	Group O	p-values*
	Mean±SD	Mean±SD	
At baseline	46.89±18.97	54.79±24.71	0.170
6th week	32.93±15.92	34.10±19.72	0.801
12 week	20.01±10.20	22.88±14.13	0.371

[Table/Fig-5]: Difference in PTH values over time between two groups.
*two sample independent test is used

DISCUSSION

In present study, 86.67 % were found to be vitamin D deficient and 13.33% were Vitamin D insufficient according to Holick MF (Global Prospective 2013) [2].

Zhang D et al., did the study on 527 patients, 71% of the patients with fracture had low vitamin D levels [22]. In a study by Hershkovitz A et al., 92.6% of the patients had lower cholecalciferol levels, in which 78.2% were vitamin D deficient and 14.4% were vitamin D insufficient. 6.8% of the patients had optimal vitamin D level. Cholecalciferol deficiency was found in 20.3% of the patients [23].

The vitamin D mean value was significantly raised with the time in group I and group O at 6th weeks and still remained increased at 12th weeks in group I but not in group O which implied better results in vitamin D level in group I, as compared to group O. Billoo A et al., and Hashemipour S et al., have done similar studies comparing two different routes for Vitamin D supplementation and found similar results [24,25].

Previous studies by Gupta N et al., Robertson DS et al., and Lakkireddy M et al., reported similar observations regarding the safety, efficacy and acceptability of a single dose of vitamin D versus oral vitamin D [20,26,27]. Vitamin D (cholecalciferol) was found to be helpful in both oral and injectable forms. The vitamin D value at 6th weeks increased for both groups 40.94±4.67 ng/mL for group I and 33.64±9.89 ng/mL for group O as compared to their baseline values which were 13.84±3.54 ng/mL and 16.45±6.3 ng/mL for group I and group O respectively.

Although, the results after administration of injectable form were statistically significant as at 12th weeks vitamin D values sustained and showed increase in injectable group compared to group O as evident from the values 44.52±7.09 ng/mL for group I and 24.65±10.92 ng/mL for group O. There were no negative side effects, and both treatment options were well tolerated.

Significant changes were observed in the serum calcium levels from baseline within the groups which declined at 6th weeks followed by rise at 12th weeks. Statistically no significant difference was observed in the mean calcium levels between both the groups at 12th weeks. These observations were similar with studies conducted by Mittal H et al., [28]. They investigated the non inferiority of a lower therapeutic dose (3,00,000 IU) of vitamin D for boosting blood 25(OH)D levels when compared to a conventional dose (600,000 IU) [28]. They discovered hypercalcemia in two children at 4th weeks (one in each group) and three children at 12th weeks (one in group 1 and two in group 2). It was concluded that initially calcium level were decreased initially and then increased.

Difference was observed in the serum ALP from baseline within the groups. The mean serum ALP which in both the groups decreased at 6th and 12th weeks. Statistically no significant difference was observed in the mean ALP levels between both the groups at 12th weeks. This was similar to the outcome of the study conducted by Mittal H et al., both the groups demonstrated significant (p-value <0.05) and comparable fall in the serum alkaline phosphatase levels at 12th weeks [28].

Vitamin D deficiency have been observed to often have raised serum PTH levels. The mean serum PTH respectively in the group I and group O which showed a significant decrease in the levels at 6th weeks and 12th weeks. Statistically no significant difference was observed in the mean PTH levels between both the groups at 12 weeks. The PTH values were higher than normal range in many patients and may be attributed to higher ages of the subjects. This finding is consistent with that reported by Haden ST et al., where it was observed that both the study groups demonstrated significant (p-value <0.05) and comparable fall in the serum parathormone levels at 12 weeks. Relative change {ratio of geometric mean (95% CI)} in serum PTH, 12th weeks after therapy, were 0.98 (0.7-1.47) [29]. Choi HK et al., assessed the efficacy and safety of high dose vitamin D3 after intramuscular injection and found that decreased levels of PTH in the vitamin D3 group when compared to control group [30]. Haden ST et al., also observed that in both the groups, efficacious PTH suppression were observed. A single intramuscular dose of vitamin D3 had no meaningful effect on PTH. It was concluded that both the groups showed statistically significant suppression of PTH from baseline [29].

Reduced vitamin D levels may also have a role in the occurrence of hip fractures in these older people, especially if they also have osteoporosis, as suggested by the data. These studies demonstrated that calcium and vitamin D supplementation is safe and induced a moderate reduction in femoral neck bone loss associated with a substantial reduction of the risk of hip fracture in elderly ambulatory women. Previous research by Sanfelix-Genovés J et al., and Diez A et al., has shown that oral vitamin D replacement has a low rate of compliance [31,32]. Pearce SH and Cheetham TD, suggested an i.m. dose of 300,000 IU cholecalciferol once a month for three months followed by the same

dose once or twice a year in patients with severe malabsorption [33]. The pharmacokinetics of i.m. D3 delivery, as well as the lack of 25(OH)D level variations after i.m. treatment, makes it a good therapeutic choice for people who have obesity, malabsorption, or compliance issues as suggested by Vieth R [34]. Kaur P et al., found that excessive doses and injudicious usage of the parenteral route, on the other hand, may be linked to problems including hypercalcemia, hypercalciuria and vitamin D toxicity [35].

CONCLUSION(S)

Present study established an association between hypovitaminosis D and intramuscular injection of vitamin D. It was concluded that although both administration routes are effective and appear to be safe, intramuscular application is more effective in increasing 25(OH) D levels and sustaining it for a longer period of time as compared to oral dose. Identifying and treating these patients early with vitamin D for osteomalacia and anti osteoporotic regimens for osteoporosis will improve the bone, muscle and overall health thereby reducing falls and fractures. Studies on larger scale are needed to be carried out to set the inferences on right dosage of vitamin D.

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THE KEY ROLE OF VITAMIN D IN FEMALE REPRODUCTIVE HEALTH: A NARRATIVE REVIEW

Shkiryak A.
CEO and chief medical officer "Shkiryak Clinic"
Ukraine
Neurosurgeon
MD, MsSc
ORCID: https://orcid.org/0000-0002-2282-8285
Khanenko S.
"Shkiryak Clinic"
Ukraine
Family doctor
MD, MBA
ORCID: https://orcid.org/0009-0000-4237-1158
DOI: 10.5281/zenodo.18081751

Abstract

Vitamin D, besides its crucial role in bone health and immune function, has received increased attention in recent years due to its possible impact on many processes related to female reproductive health. Recent research has tried to explain the role played by vitamin D in maintaining adequate hormonal status, fertility, and pregnancy outcomes. Our aim for this narrative literature review was to highlight and explain the mechanisms through which vitamin D status impacts female reproductive health. We believe this represents a very important subject of research, especially due to the increased incidence of infertility nowadays. Further studies are necessary on the association between vitamin D status and female reproductive health in order to fully understand its effects and to reach a consensus regarding vitamin D supplementation as a method to improve fertility status.

Keywords: ergocalciferol, cholecalciferol, vitamin d status and pregnancy outcomes, vitamin d deficiency and hormonal balance, vitamin d and women's health, female fertility.

INTRODUCTION AND BACKGROUND

Female reproductive health includes the proper functioning of the reproductive system, menstrual cycle, hormonal balance, and the ability to conceive and sustain a pregnancy (1). Various factors influence female reproductive health, including genetics, lifestyle, environmental exposures, and nutritional status. Recently, vitamin D status has been promoted as a significant factor regarding reproductive health due to its many biological roles.

To understand how vitamin D status affects female reproductive health, it is important to describe first its metabolism and principal effects on the human body. Vitamin D2 (ergocalciferol) and vitamin D3 (cholecalciferol) are the two most significant forms of vitamin D, each playing a crucial role in human health (2). Sunlight exposure on the skin is the primary source of vitamin D, which can also be extracted from the diet, particularly in the forms of vitamin D2 and D3, as well as other less nutritious forms of vitamin D (3).

Vitamin D2 and D3 are converted into hormonally active forms through metabolism, first in the liver, then followed by the kidney. Due to its fat-soluble composition, vitamin D enters the bloodstream as a complex with a particular alpha1 globulin, known as the vitamin D transporter protein (4). The first step in this process is the hydroxylation of vitamin D in the liver, producing 25-hydroxyvitamin D (25-(OH) D). The second hydroxylation of 25-OH vitamin D occurs in the kidney, resulting in the most important metabolite of vitamin D, 1,25-(OH)2 vitamin D, which is produced in the renal proximal tube by 1-alpha hydroxylase (5). It's worth noting that the placenta and granulomatous tissue also play a significant role in synthesizing 1,25-(OH)2 vitamin D, serving as extrarenal locations for this process (5).

The main regulator of vitamin D metabolism is renal hydroxylation, a process influenced by blood calcium, phosphate, and parathyroid hormone (PTH) concentrations. Two significant factors, PTH and hypophosphatemia, work independently to enhance vitamin D 1,25-(OH)2 by increasing renal 1-alpha hydroxylase activity. Additionally, hypocalcemia boosts PTH secretion, increasing the kidneys' synthesis of 1,25-(OH)2 vitamin D (2-4). The most accurate instrument for vitamin D status measurement is represented by 25 hydroxy-vitamin D.

Vitamin D optimal status is necessary for maintaining bone health, strengthening the immune system, and modulating several metabolic functions. According to Mayo Medical Laboratories, 25(OH)D serum values between 20-50 ng/mL represent optimal vitamin D status (6). Despite its availability, vitamin D deficiency is a common health issue worldwide, affecting various populations, including women of reproductive age (1).

Vitamin D's effects on female reproductive health have been an important research topic recently. Adequate vitamin D levels have been associated with improved fertility, healthier pregnancies, and reduced risk of reproductive disorders such as polycystic ovary syndrome (PCOS) and endometriosis (1,7). Studies have shown that vitamin D affects fertility through its role in the synthesis of sex hormones. Research from Yale found that only 7% of 67 infertile women had adequate vitamin D levels (7). Simultaneously, research has demonstrated a strong correlation between the body's vitamin D levels and the success rate of in vitro fertilization.

Besides the impact on fertility, vitamin D is also essential for pregnant women and infants. Recent research has indicated that optimal vitamin D status supports the development of the fetal skeleton and immune system and may reduce the risk of complications such as preeclampsia, gestational diabetes, and preterm birth (6,8,9). For infants, optimal vitamin D levels are essential for healthy bone development and may reduce the risk of developing rickets and other health issues (1).

This narrative literature review aims to present the evidence linking vitamin D status to various aspects of female reproductive health. We conducted intensive research on original articles, reviews, and meta-analyses published in international databases such as PubMed, Web of Science, Cochrane, and Google Scholar. In order to appropriately identify the studies, we used keywords such as “vitamin D and health status”, “vitamin D and women's health”, “female reproductive health and vitamin D”, “vitamin D deficiency and hormonal balance”, “vitamin D status and pregnancy outcomes” and “vitamin D status and fertility". By synthesizing findings from observational studies, clinical trials, and meta-analyses, we sought to provide a comprehensive understanding of how vitamin D influences reproductive outcomes and to highlight potential implications for clinical practice. The conclusions of the included studies were summarized and analyzed using the narrative synthesis method in order to describe the results in a comprehensive way.

REVIEW

Vitamin D and general health status

Despite its classification as a vitamin, vitamin D functions more like a hormone, influencing various systems in the organism. Its importance extends beyond bone health, impacting immune function, cardiovascular health, mental health, and even chronic disease prevention.

The innate and adaptive immune systems, pancreatic β cells, and the circulatory and cerebral systems are among the targets of vitamin D (10). Therefore, vitamin D can influence cell division and proliferation, immune response modification, and hormonal production (11). Taking into consideration its implication, vitamin D supplementation may be helpful in preventing and treating specific illnesses.

One of vitamin D's most well-known roles is maintaining bone health. It is known that conditions such as rickets in children and osteomalacia or osteoporosis in adults are direct consequences of vitamin D deficiency (12).

Due to its implication in regulating immune function, adequate vitamin D levels can help reduce the risk of various infections. Vitamin D optimal status may also play a role in preventing autoimmune diseases like multiple sclerosis and rheumatoid arthritis by lowering the level of inflammatory cytokines (12). Studies have indicated that optimal vitamin D levels can positively impact the immune system by activating B cells, T cells, and antigen-presenting cells (13,14).

Regarding cardiovascular pathology, research indicated that an elevated risk of cardiovascular disease is linked to a poor level of vitamin D (15,16). In a recent examination of the Framingham research, patients without a history of cardiovascular illness had their levels of 25-hydroxyvitamin D tested (2,16). It was shown that patients with hypertension whose 25-hydroxyvitamin D level was less than 15 ng/ml had a 62% increased risk of cardiovascular events compared to those whose level was 15 ng/ml or higher (16-18).

According to research vitamin D receptors are also present in the brain and play an important role in brain development and function (19, 20). Vitamin D deficiency has been associated with an increased risk of depression, anxiety, and cognitive decline, therefore ensuring adequate vitamin D levels may support mental health and cognitive function, particularly in older adults (19, 20).

These findings confirm the idea that vitamin D may have a key role in health status during different periods of life on many systems and support the need for further research regarding its actions.

The impact of vitamin D status on female reproductive health

Vitamin D Status and Menstrual Cycle Regulation

Nowadays, the majority of women of reproductive age have experienced at one point at least one episode of menstrual cycle dysregulation. This can be partially explained due to increased levels of everyday stress and external factors that can affect the hormonal axis. Studies have shown that vitamin D can regulate the menstrual cycle, and adequate vitamin D levels may help maintain normal ovulation and menstrual regularity. Vitamin D receptors (VDRs) found in human and animal granulosa and cumulus oophorus cells prove that Vitamin D is crucial in regulating the menstrual cycle (21, 22).

Vitamin D's impact on hormonal regulation among women represents a hot topic of research and implies several physiological processes (23). The primary hormone affected by vitamin D status is estrogen, and alteration of its normal levels leads to many dysregulations among women of reproductive age. Due to vitamin D binding to VDRs, the expression of genes involved in the synthesis and metabolism of estrogen is regulated by it. It was shown that vitamin D can increase the production of aromatase, which represents an essential enzyme involved in converting androgens to estrogen (23,24). Vitamin D receptors are also present in the hypothalamus and pituitary gland, which suggests the possible influence of vitamin D on the release of gonadotropin-releasing hormone (GnRH) (25). GnRH normal levels are essential for adequately releasing luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the pituitary gland, with a vital role in estrogen production and menstrual cycle regulation. Another important hormone influenced by vitamin D is represented by progesterone (23). Several studies demonstrated that vitamin D increases the function of the corpus luteum, therefore ensuring adequate progesterone production, which is critical for menstrual cycle regulation (26).

Vitamin D also impacts insulin regulation, as shown by different studies (25,27). It is widely known and accepted that increased insulin resistance is associated with menstrual cycle dysregulation. Vitamin D de-

ficiency has been linked with increased insulin resistance, which can affect ovarian function and hormonal status (25,28).

It has also been associated with menstrual disorders, including polycystic ovary syndrome (PCOS), which is represented by irregular menstrual cycles and hyperandrogenism, mainly associated with insulin resistance (29). A clinical trial by Salehpour et al. concluded that vitamin D supplementation in cases with deficiency can decrease insulin resistance in women with polycystic ovary syndrome (30). Supplementing with vitamin D can also reduce the excessively high levels of anti-Mullerian hormone (AMH) in the blood and enhance the levels of anti-inflammatory soluble receptors for advanced glycation end-products in women with PCOS who have a deficiency in vitamin D (31). Specifically, the administration of vitamin D and calcium, together with metformin treatment, in women diagnosed with PCOS may lead to positive outcomes in terms of monthly regularity and ovulation (31-33).

A 2018 study by Lagowska assessed vitamin D levels in the bloodstream and compared them with the menstrual cycle in young women [34]. It showed that decreased levels of 25(OH)D were linked to longer menstrual periods, namely oligomenorrhea or amenorrhea. Those with 25(OH)D levels below the recommended threshold of 30 ng/mL had nearly five times the likelihood of experiencing menstrual cycle problems compared to those with levels above 30 ng/mL (34).

Singh et al. found that women with regular menstrual cycles had notably elevated levels of vitamin D, whereas decreased levels of vitamin D were linked to a 13-fold increase in the likelihood of experiencing an irregular menstrual cycle (35).

Vitamin D Status and Fertility

As we know, in the past years, global fertility rates have been declining, representing a major health problem. It is known that lifestyle and environmental factors are directly implicated in this process. Additionally, sedentary lifestyles, poor diet, stress, and exposure to environmental toxins can adversely affect reproductive health. Conditions such as obesity, diabetes, and polycystic ovaries syndrome which have registered an increased incidence lately, have also a great impact on fertility (7).

The presence of vitamin D receptors in the ovaries, endometrium, and placenta suggests that vitamin D plays a role in reproductive processes (36,37). As described above, the mechanism through which vitamin D status impacts fertility and hormonal status among women of reproductive age is complex (25). Adequate vitamin D levels are associated with improved fertility outcomes, including higher conception rates and successful pregnancy development. Optimal vitamin D status is also linked to better outcomes in assisted reproductive technologies (ART), such as in vitro fertilization (IVF) (25). Many studies have demonstrated a correlation between low vitamin D levels in the bloodstream and decreased natural fertility and the efficacy of IVF (29).

A particular subject of interest is vitamin D serum levels in follicular fluid (25). A prospective study tried to establish if 25-hydroxyvitamin D serum values in the follicular fluid among women experiencing in-vitro fertilization are associated with the procedure's outcomes (38). It was shown that optimal vitamin D status was correlated with an increased likelihood of achieving a pregnancy following in-vitro fertilization (38). In contrast to these findings, another study investigating the values of 25-hydroxyvitamin D from follicular fluid found that insufficient vitamin D levels do not significantly impact the outcome of in-vitro fertilization (39). The inconsistent findings may be related to the relatively small study group.

Zhou et al. studied the impact of vitamin D supplementation on pregnancy rates after in vitro fertilization in a meta-analysis from 2022. It involved five prior studies and concluded that achieving an optimal vitamin D status by using supplements improved the rate of chemical pregnancy, but regarding rates of clinical pregnancy, there wasn’t enough evidence (40).

The status of vitamin D before ovarian stimulation represents another important aspect of fertility research. A 2022 study conducted in Hong Kong analyzed this and concluded that after the first in-vitro fertilization cycle, the live birth rate was lower in cases of vitamin D deficiency than in optimal vitamin D status (41).

A meta-analysis conducted by Chenhao Xu et al. in 2024, consisting of 23 separate research, provides strong evidence indicating a possible association between blood vitamin D levels and the results of ART (42). This research suggests that women who maintain adequate vitamin D levels are more likely to have successful live births, positive pregnancy tests, and clinical pregnancies after having ART treatments. On the other hand, those who have inadequate amounts of vitamin D have a lower likelihood of reaching these positive results (42).

Vitamin D Status and Pregnancy Outcomes

Despite the efforts of several worldwide studies, there is still disagreement on the relationship between low vitamin D levels and the emergence of obstetric complications. Pregnant women often develop vitamin D insufficiency, shown in the blood levels of 25 hydroxyvitamin D in both the mother and the fetus. Especially when the need for vitamin D increases during pregnancy, a deficiency may harm the fetus's adequate development and the mother's health (1). Recent research suggests that the effects of vitamin D insufficiency during pregnancy may be considerably more significant than previously believed.

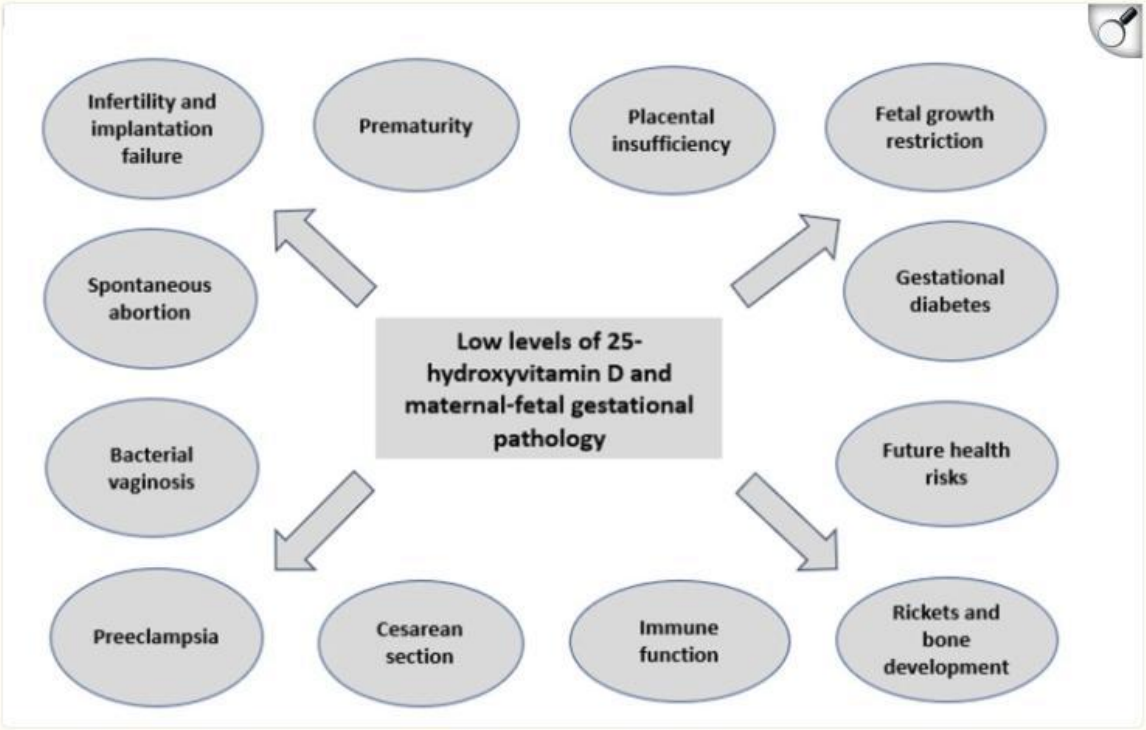
According to studies, a balanced diet is insufficient to meet a pregnant woman's needs for vitamin D, iron, and folic acid. Consequently, food consumption often does not surpass 2-2.2 μg of vitamin D per day, even though the daily need is at least 5 μg (43). This is further supported by the observation that low levels of 25-hydroxyvitamin D (25-(OH)D), the most extensively used marker of vitamin D status regardless of source, are frequently found in pregnant women. Even in developed nations with less common nutritional rickets, vitamin D deficiency during pregnancy remains a significant concern.

A moderate vitamin D deficit is commonly defined as a blood level of less than 20 ng/ml (50 nmol/L), while a severe deficiency is defined as a level below 10

ng/ml. Mayo Medical Laboratories states that while 10-19 ng/mL indicates mild to severe insufficiency, the 25-hydroxyvitamin D2 and D3 value is ideal in the range of 20-50 ng/mL. A significant insufficiency of vitamin D is indicated by levels below 10 ng/ml (6,10). It is advised that pregnant women have an ideal circulating 25-(OH)D level of at least 40 ng/ml from the start of their pregnancy. (10) Research indicates that this level should offer the highest level of protection against conditions such as the newborn's asthma or pregnancy-related complications such as preeclampsia (1). It is crucial to remember that season, amount of sun exposure, and dietary habits may all affect 25-hydroxyvitamin D levels.

Even though vitamin D deficiency has been linked to osteoporosis and rickets, it is now widely acknowledged that vitamin D regulates many other biological processes. Certain tissues that can be broadly referred to as "barrier sites" have been found to express the VDR for the active form of vitamin D, 1,25-dihydroxy vitamin D (1,25(OH)2D), as well as the enzyme 1α-hydroxylase that synthesizes 1,25(OH)2D (CYP27B1) (37). This suggests that particular responses to vitamin D may be a key feature of these tissues (44, 45). The placenta is the most common "barrier site". In the past, the placenta was among the earliest extrarenal tissues to produce 1,25(OH)2D, with fetal trophoblast and maternal decidua both presenting CYP27B1 activity (46, 47). International research has also shown the connection between vitamin D status and the placenta during pregnancy. Vitamin D modulates placental implantation, assisting in generating cytokines and the proper immunological response in the event of infection. On the other hand, the placenta manufactures vitamin D and reacts to its activity. Taking this into consideration, it is safe to say that vitamin D status can be associated with maternal-fetal complications during pregnancy (1,8). The main pregnancy-related complications associated with vitamin D deficiency are presented in Figure 1 (1,8).

Figure 1. Vitamin D deficiency and pregnancy-related complications.



The benefits of vitamin D supplementation during pregnancy, either alone or combined with other micronutrients, were compared to a placebo or no intervention in a 2019 Cochrane study by Palacios (48). Evidence from 22 trials totaling 3725 pregnancies indicates that pregnant women who only take vitamin D supplements may be at decreased risk of severe postpartum hemorrhage, low birth weight infants, gestational diabetes, and preeclampsia when compared to placebo or no intervention. According to the review's findings, vitamin D supplementation does not seem to have concrete evidence of lowering the risk of preterm delivery at less than 37 weeks gestation (5, 11, 48).

During pregnancy, there are significant changes in the mother's calcium metabolism and vitamin D levels. Serum levels of 1,25 (OH)2D, which are larger in the case of pregnant women's circulation compared to the fetal circulation, might enhance the transit of vitamin D from mother to fetus, even though transplacental transport has not been examined in humans (44, 45). Pregnancy causes an increased 1,25(OH)2D production in the kidneys. The CYP27B1 enzyme also produces a

significant 1,25(OH)2D quantity in the decidua and placenta (37). Furthermore, the transcription of this gene is repressed by specific methylation of placental CYP24A1 (47).

Studies have shown that vitamin D deficiency in gestational diabetes is likely largely influenced by increased CYP24A1 activity in the placenta. 25(OH)D is hydroxylated by CYP27B1 into the bioactive form 1,25(OH)2D, and CYP24A1 catabolizes both 25(OH)D and 1,25(OH)2D to inactive metabolites (49). Furthermore, it has been proposed that vitamin D deficiency increases the likelihood of developing glucose intolerance. It was demonstrated that large dosages of vitamin D supplementation decrease insulin resistance in gestational diabetes-affected pregnancies (50).

Vitamin D molecules' production, metabolism, and function during pregnancy are intricate processes. The human endometrial decidua produces 24.25(OH)2D while the placenta synthesizes 24.25(OH)2D (47). The placenta's VDR content indicates that vitamin D may directly affect certain tissues during pregnancy (51). A plausible interpretation is that 1,25(OH)2D functions as a modulator of calcium transport in the placenta; nonetheless, the placenta's immunomodulatory function has also been suggested (51,52). Furthermore, vitamin D may be essential for conception, implantation, and placenta formation due to the quick expression of VDR and CYP27B1 early in pregnancy (53). In addition, vitamin D is critical in controlling perivascular support and neovascularization, suppressing placental neoangiogenesis and vascular development (54).

Many studies indicate that vitamin D insufficiency is linked to a higher risk of preeclampsia during pregnancy (55). A substantial correlation has been shown in cross-sectional research between vitamin D deficiency and the likelihood of preeclampsia and its related consequences (56). Vitamin D deficiency is described as one of the risk factors for the onset of preeclampsia (57). The placental gene transcriptions are known to be altered by maternal physiological levels of 25(OH)D. This alteration includes decreased antiangiogenic factors, which may impact the risk of vascular complications during pregnancy. There is also evidence for an immunological cause and potential toxicity in preeclampsia linked to autoimmune diseases. The significance of maintaining optimal vitamin D status throughout pregnancy to reduce the risk of preeclampsia is highlighted by these findings.

Vitamin D deficiency as a risk factor for intrauterine growth restriction and associated placental insufficiency was described in various studies. Even though intrauterine growth restriction has been mostly attributed to placental insufficiency, maternal malnutrition may also have an important contribution (58). As we presented before, vitamin D has a key role in placental development; therefore, its impairment affects normal fetal growth and development. It was shown that the average vitamin D level of pregnant women whose newborns displayed intrauterine growth restriction was 33% lower than that of women whose babies displayed normal intrauterine development at delivery (59).

Another important topic is the fact that increased vitamin D serum levels have been linked in other studies to a decreased risk of both spontaneous and induced preterm birth brought on by a variety of medical conditions, including diabetes mellitus, hypertension, and prior preterm delivery. Research has also demonstrated that adequate vitamin D levels protect against miscarriages (60) and that women who had a normal pregnancy and delivery had considerably increased vitamin D status compared to those who had a spontaneous abortion (60,61).Women who have repeated miscarriages and hypovitaminosis D are more likely to experience autoimmune diseases and cellular abnormalities than women who experience repeated miscarriages and normal vitamin D levels (60).

It was described that pregnant women who consume less than 400 IU of vitamin D daily are at a heightened risk of miscarrying (62). Furthermore, a study compared women with low 25(OH)D levels to those with a level of 26.4 ng/ml, and it was revealed that in cases with adequate vitamin D status, there was a four-fold increased risk of successful reproduction (63). According to a study by Hollis et al., women who received 4,000 IU of vitamin D per day as dietary supplements had a 50% lower risk of preterm delivery and a 25% lower risk of maternal infection than those who received 400-2000 IU per day (64).

Due to vitamin D's role in immune functions, bacterial vaginosis has been linked to a higher risk in pregnancies associated with vitamin D deficiency (65). This condition can cause discomfort to pregnant women and affect the viability of a pregnancy (66). In addition, miscarriages, early membrane rupture and preterm delivery, chorioamnionitis, and postpartum endometritis have been linked to bacterial vaginosis (65,66). Effective, adequate antibacterial, and anti-inflammatory responses are necessary for a normal pregnancy (65). Studies have shown that adequate vitamin D levels enhance the body's ability to fight off infections in both the placenta and the genital tract (65). In one research, for instance, 440 pregnant women were shown to have a three-fold increased risk of bacterial vaginosis if their blood 25(OH)D levels were below 30 ng/mL (66).

It is thought that low levels of vitamin D in maternal serum also raise the possibility of cesarean delivery (67). According to one research, women with a 25(OH)D level below 15.2 ng/ml had a roughly four-fold higher incidence of cesarean sections than those with a level over 15.2 ng/ml (68). Methodological variability across studies and the wide range of reasons for elective and emergency cesarean sections severely limit a more appropriate assessment of the influence of vitamin D on the completion of cesarean procedures. Therefore, currently, there is a lack of sufficient data to prove the association between a pregnant woman's risk of cesarean birth and a vitamin D deficiency.

Taking into consideration the link between vitamin D deficiency and the multitude of pregnancy-related complications, further research and randomized clinical trials are necessary to fully understand the underlying mechanisms.

CONCLUSIONS

Vitamin D status greatly impacts female reproductive health by influencing menstrual cycle, fertility, and pregnancy outcomes. To maintain an optimal health status among fertile women, adequate vitamin D levels must be ensured through a combination of sunlight exposure, diet, and supplementation.

Given the high incidence of vitamin D deficiency, especially in pregnant women, monitoring and managing vitamin D status should be a “gold standard” for any medical practitioner. Further research is still needed to reach a consensus on the impact of vitamin D status on female reproductive health and to completely understand the mechanism that influences fertility and pregnancy-related complications.

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PEDAGOGICAL SCIENCES

METHODS OF USING NEW INNOVATIVE METHODS IN TEACHING

Garashova M.
Sumgait State Technical College under Sumgait State University
https://orcid.org/0009-0002-5659-2386
DOI: 10.5281/zenodo.18081778

Abstract

In the modern era, the future fate of every nation and state is determined not only by the rich natural resources it possesses, but also by its scientific, cultural and intellectual capabilities, and above all by its human capital. This invaluable capital, the functional capabilities of which are realized through the application of science and education in the most diverse areas of public life, acts at the present stage as a guarantee of the future development of individuals and public societies, in a broad sense, of the peoples, their standard of living, as well as their achievements. A person who understands his national identity and preserves the historical and cultural heritage of the people to which he belongs, The main task of our education is to raise a personality who can become a full-fledged citizen in society in the future. In terms of the requirements of the XX century, in addition to preserving the successes of traditional education, the application of innovations and new pedagogical technologies should be considered as important conditions for improving the quality of education. For this reason, hundreds of new concepts have entered our education as innovations. Life skills-based education, curriculum, e-school, ICT, distance learning, active and interactive methods, portfolio, Bologna process, synergistic education, constructive education, synectics in education, etc. Are important areas and methods of innovative education, being new concepts of our education.

Keywords: education, innovative, application, curriculum, teaching, methods.

Introduction - Presentation, which is one of the important elements of lessons conducted with active (interactive) teaching methods, should be considered an indicator of the student's research activity. This method allows students to present the results of the research in various ways, to acquire the ability to express their ideas accurately, and to draw excellent conclusions. When a student preparing for a presentation works in a group, he acquires a culture of communication and is able to share ideas. In this case, the presentation he (she) prepares is accurate, or attracts attention with its design [1, p. 10–12].

Students preparing for a presentation learn the rules for how to conduct a presentation. The teacher should instruct students on the type of presentation and the rules for conducting it. A student who follows these instructions is prepared in advance to use time effectively and express his/her ideas more precisely and concisely. He/she is able to comment on the presentation while conducting it. The presentation is discussed and evaluated based on a criteria table. This is one of the research methods and creates conditions for a comprehensive study of the subject. Through cubing, the student is guided to describe and compare, correlate, analyze, apply and argue the subject. At this time, the student's critical and logical thinking develops, a comprehensive view of the subject, evaluation skills, and cooperation habits are formed.

The main goal of the modern education system is not only to impart knowledge, but also to guide students to think independently, solve problems, and be creative and critical. In this regard, active learning methods offer a completely different approach from traditional learning. Active learning ensures that the student is not a passive, but an active participant in the learning process. Through it, the lesson becomes an interactive, dialogue-based and collaborative process, rather than a monotonous transfer of knowledge. Active learning is the basis of modern pedagogy, XX century skills, and effective preparation for the next generation.

Active learning methods develop students' creative thinking, social skills, and personal initiative. These methods attract the attention of children at every stage of the lesson, encourage them to independent research and joint cooperation. In active learning, the teacher is not only a source of knowledge, but also an organizer and guide of the learning process. Students do not just accept ready-made information, but build knowledge on their own experience and ensure their individual development.

Active learning refers to learning that is based on the active cognitive activity of students and is carried out in collaboration with other participants in the educational process. Often, the concept of "interactive learning methods" is used as a synonym for this concept. Thus, the term "interactivity" means "dialogue, interaction." The concepts of "problem dialogic", "problematic", "heuristic learning" are also used to express this learning method. The active (interactive) learning method is a learning method based on the above modern principles. Active (interactive) learning is a set of methods for organizing and managing teaching and cognitive activity. The following features are characteristic of this learning:

The teacher consciously (voluntarily) creating a cognitive problem situation,

Stimulating students' active research position in the problem-solving process;

Creating conditions for students to independently discover, acquire and master new and necessary knowledge.

The essence of the new approach is that the training is aimed not only at enriching the memory of students with new scientific knowledge (information), but also at the independent acquisition and assimilation of more knowledge, the acquisition of the most important

skills and habits, personal qualities and abilities, based on the regular development of thinking. At this time, students, under the guidance of a teacher, learn to identify cause-and-effect relationships and regularities of facts and events, draw conclusions, and make important and deep generalizations in the process of studying specially selected, easily understandable and memorable, most important training material.

The student's position is that of "discoverer", "researcher"; when faced with issues and problems that he is capable of, he solves them in an independent research process. Students, as full participants in the learning process, act as researchers in this process and acquire knowledge in the process of active search and discovery.

The teacher's position is that of a facilitator ("guide", "leader"), organizing problem situations in a planned and directed manner, and presenting research questions to students.

It creates conditions for the formation of creativity and improving the quality of education. The efficiency of training (the ability to absorb more information in a shorter period of time) is significantly increased. The following reasons can be cited for this: Due to students' cognitive activity and learning motivation;

Through independent, productive and creative acquisition and assimilation of knowledge based on thinking.

The application of active (interactive) learning changes the school environment, increases students' self-confidence, improves interpersonal relationships, makes their attitude towards school and studying more positive, and forms the habits of independently acquiring knowledge, acquiring new ones, and using them to achieve life goals.

Thus, the necessity of active (interactive) learning lies primarily in the fact that the formation of such abilities in the personality allows for adaptation to constantly changing conditions and its effective integration into life.

World experience shows that the active (interactive) teaching method can be an important tool for the teacher to improve the quality of the lesson. This method makes the lesson very interesting and attractive for students. Active (interactive) teaching makes both the learning of the content of the lesson and the application of this content more efficient, and makes the students' cognitive activity more active. As the students' enthusiasm for learning and their achievements increase, the teacher's activity also becomes easier. However, this does not mean that the teacher's work is reduced. Preparing an active/interactive lesson requires more effort from the teacher at the planning stage.

Despite the advantages of active (interactive) learning, the teacher should not completely abandon the use of traditional (explanatory-illustrative and reproductive) methods.

The integration of new pedagogical strategies encourages critical thinking and problem-solving skills among higher education students.

Modern society is undergoing dynamic changes characterized by numerous innovations. With the rapid development of science and technology, the application of innovations is manifested in education, as in all areas. This creates the need to make changes in the content and organization of innovative activities in educational institutions. There is a need to improve education on the basis of new economic relations that have formed in the country, and to regularly update the pedagogical process. This update is associated with modern innovation searches and pedagogical activities. Innovations in education are innovations in which new technologies and methods are applied. In modern times, the need for educational innovations has increased even more, because the social and economic well-being of countries increasingly depends on the quality of education of citizens. Society already supports those with high skills and knowledge. Today's education system is required to improve the quality of education by using both effective and efficient resources.

Interactive teaching is one of the special forms of organizing cognitive activity. It has specific current and future goals. The main goal is to create conditions for training and education in which students or listeners feel successful and intellectually capable; Thanks to this, the process of teaching knowledge, skills and habits will be more productive, and a basis will be created for solving problems in real life after graduation.

In other words, the interactive method in teaching and learning can be considered a form of teaching in the form of dialogue in which the teacher and students are in constant communication with each other throughout the entire allotted time. The objectives of interactive learning forms are as follows:

- Arousing interest in students or listeners;
- Effective mastery of educational material;

Solving the task given to students or listeners:

- Their free search for ways and options (if any option is preferred, its justification);
- Teaching students to work in a team, be tolerant of others' views, and respect everyone's right to freedom of speech and sense of self;

Don't express your opinion, students will have opinions.

- Formation;
- Creation of life and professional habits;

Student's perceived competence (skill). When using interactive teaching methods, the teacher changes the role of the central figure, becoming the regulator of the learning process. Experienced teachers and educators say that there is no child who does not want to read, who is not interested. From the moment a child is born, he or she is eager to learn and understand the world around him or her, and they are interested in everything. [4, p. 20–22].

From what has been said, it is clear that interactive methods significantly improve the quality of teaching, form new cognitive and moral qualities in students: listening to the interlocutor, any speaker (speech), tape recorder, radio, television programs, respecting the ideas expressed, expressing an attitude when appropriate, thinking independently, critically and creatively, expressing opinions freely, defending and proving the idea put forward, developing logical thinking, analyzing experience and general preparation, objectively as-

sessing oneself, seeing one's place in the team, cooperating with members of the team in the process of mental and physical labor, working together, performing one's share of the common work with dignity, being active and diligent in forming the opinion of the team, making decisions together with members of the group, the class team, defending oneself in the event of a conflict, resolving the conflict patiently and peacefully, being tolerant, taking risks, controlling oneself in emotional situations, controlling oneself, taking responsibility for one's personal health. to be able to carry, to treat people and their rights with respect and justice, etc.

In lessons taught using interactive methods, students' curiosity and initiative increase, their learning activity increases, and the quality and efficiency of teaching increases. As a result, creative thinking develops, not mechanical memory. The use of technology increases interactivity in English language lessons [5, p. 15–17].

Interactive learning is a learning process conducted using democratic methods that contributes to the acquisition of knowledge, skills, experience, and habits, and the development of social and intellectual thinking, independent work, and independent thinking skills necessary for citizens of society. [6, p. 32–34].

While interactive learning refers to the inter-student learning, teaching, communication and collaboration that occurs in the lesson, teacher-student unity and cooperation, interactive methods refer to the methods, styles, tasks, approaches, and tools that enable students to learn and understand, acquire skills and qualities in the learning process.

The results of the latest research show that interactive learning methods give effective results by closely applying ICT to training, referring to the theory of constructivism, and make their functionality even more efficient. Psychologists note that information remains in the memory of a person 10% of what he hears, 50% of what he sees, and 90% of what he does himself. The great support of ICT in this area is in providing the learner with a powerful information bank during his personal research (Internet, e-books, tests and assignments, etc.).

In the interactive learning process, at first glance it may seem that the teacher does not play an active role in the classroom. In fact, the teacher becomes a "creator" who inspires the student and helps him find himself.

Interactive methods allow the teacher not only to teach others, but also to learn themselves, becoming a more creative and energetic educator.

Interactive teaching methods also require abandoning the usual layout of the classroom, the usual way of organizing classes. There are four main forms of placement of student desks in the classroom.

The criteria for the effectiveness of a modern lesson are:

- Direction towards a specifically formulated expected result;
- Orientation to the student's living, personally valuable knowledge;
- Focus on guiding and educational issues of the lesson;
- Building on the student's creative cognitive activity;
- Takes into account the individual characteristics of students,
- Takes into account dynamism and intensive training methods;
- Learning by discovery;
- The existence of discussions;
- Personality development.

It is not easy to prepare and conduct such a lesson, for this it is necessary to approach teaching activities responsibly. Today, it is not enough for a teacher to be a good subject teacher, he must know new information technologies; teach students to be able to make independent decisions, and to be responsible for them.

Modern teaching means active (interactive) teaching. What is active (interactive) teaching? "Active (interactive) teaching" is a teaching method based on the active cognitive activity of students and the realization of the educational process in cooperation with other participants. New methodological approaches increase student engagement during lessons [7, p. 40–42]. The training is intended to be held in. In recent years, many teachers in our republic have become familiar with the active learning method and have participated in various trainings.

In the modern education system, active learning and development of creative skills of students are one of the main goals. The purpose of this study is to empirically determine the impact of innovative teaching methods (active learning, interactive methods, project-based learning and technology integration) on students' active participation in the lesson and learning outcomes. The study used experimental and control groups, and students' learning activity was assessed through observation tables, tests and questionnaires. The results show that in the group using innovative methods, students' active participation in the lesson, critical thinking and problem-solving skills significantly increased. These results show that the application of innovative methods in the modern educational process increases students' motivation to learn and contributes to more effective development of their knowledge and skills.

The scientific importance of the article: Scientific importance of studying and implementing innovative teaching methods is rooted in the growing need to modernize educational systems in accordance with global technological, socio-economic and cultural transformations. In the context of the knowledge-based society of the XXI century, education is expected not only to transmit information, but also to foster critical thinking, creativity, cognitive flexibility and problem-solving abilities. From this perspective, innovative pedagogical methods provide a scientifically grounded framework for enhancing the quality, accessibility and effectiveness of the teaching–learning process.

The research significance of innovative teaching approaches lies in their potential to create learning environments based on active participation, research-oriented thinking and independent knowledge construction. Scientific investigations show that active and interactive methods engage multiple cognitive processes

simultaneously, leading to deeper comprehension, long-term retention of knowledge and development of metacognitive skills. These methods also promote social learning, collaborative problem-solving and communication competence—key components of modern educational psychology.

Furthermore, the scientific importance of the topic is associated with the integration of digital technologies and ICT-based tools into the curriculum. Digital innovation transforms traditional pedagogical paradigms, enabling the use of data-driven instruction, adaptive learning systems, simulation-based activities and virtual collaboration. These technologies enhance the precision, efficiency and personalization of learning, which is supported by contemporary research in educational technology and cognitive science.

The study of innovative teaching methods also contributes to the refinement of teacher professional development programs by identifying new methodological competencies, instructional strategies and assessment models that respond to the dynamic needs of learners. As global educational standards shift toward student-centered, competency-based frameworks, scientific analysis of innovative methodologies becomes essential for shaping future curricula and ensuring alignment with international best practices.

In summary, the scientific importance of this research is reflected in its contribution to the modernization of education, the formation of 21st-century skills, the enhancement of teaching quality, and the development of scientifically informed pedagogical innovations capable of preparing learners for rapidly changing social and technological realities.

Conclusion - A lesson built using interactive methods differs from a traditional lesson in that here children acquire knowledge themselves, gain knowledge by working independently and searching for it. Students are actively involved in the learning process. The teacher, on the other hand, gives more direction and advice, he plays the role of a guide. The climate in the classroom leads to children's liberation, independence, and activity, children can freely express their opinions. An interactive lesson has a clear structure and allows them to solve the problems set, children acquire knowledge, and the curriculum is not damaged.

The main advantage of interactive learning is the formation of real cognitive motivation (desire to acquire knowledge). This is based on the ability to resolve real contradictions in the thinking of students in the course of cognitive activity. Emotions arising from real contradictions ensure the mobilization of mental resources, stimulate cognitive activity, and allow for long-term concentration of attention. Knowledge is acquired not in a "ready-made" form, but in the process of its independent discovery, that is, the process of assimilation is not passive, but active.

If a student discovers new knowledge based on his own desire and activity, then he approaches the lesson creatively and with interest, and assimilates the acquired knowledge for a long time and firmly.

The introduction of interactive learning methods into the educational process creates conditions for eliminating students' passivity, forming the necessary thinking skills and creativity, and improving the quality of training. The effectiveness of training (the ability to absorb more information in a shorter period of time) increases significantly. The following reasons can be cited for this: due to students' cognitive activity and learning motivation, through independent, productive and creative acquisition and assimilation of knowledge based on thinking.

World experience shows that the interactive learning method is an important tool for teachers to improve the quality of lessons. This method makes lessons very interesting and attractive for students. Active interactive learning makes both the learning of the content of the lesson and its application more efficient, and makes students' cognitive activity more active. As students' enthusiasm for learning and their achievements increase, the teacher's activity also becomes easier. However, this does not mean that the teacher's work is reduced. Interactive learning actually requires great effort, diligence and creativity from the teacher to prepare and manage the lesson. [8, p. 113-114]

It should also be noted that it is not recommended to use interactive teaching methods in teaching every subject. Interactive methods should be applied taking into account the goal set in the lesson, the content and nature of the knowledge, skills and habits to be imparted to students, integration opportunities, students' preparation, local conditions, school's material base, etc.

Sometimes you hear from teachers: "We teach well, but the students are not interested." Experience shows that interest depends on how knowledge is presented.

From what has been said, it is clear that interactive methods significantly improve the quality of teaching, form new cognitive and moral qualities in students: listening to the interlocutor, any speaker (speech), tape recorder, radio, television programs, respecting the ideas expressed, expressing an attitude when appropriate, thinking independently, critically and creatively, expressing opinions freely, defending and proving the idea put forward, developing logical thinking, analyzing experience and general preparation, objectively assessing oneself, seeing one's place in the team, cooperating with members of the team in the process of mental and physical labor, working together, performing one's share of the common work with dignity, being active and diligent in forming the opinion of the team, making decisions together with members of the group, the class team, defending oneself in the event of a conflict, resolving the conflict patiently and peacefully, being tolerant, taking risks, controlling oneself in emotional situations, controlling oneself, taking responsibility for one's personal health. to be able to carry, to treat people and their rights with respect and justice, etc.

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The results of the latest research show that interactive learning methods give effective results by closely applying ICT to training, referring to the theory of constructivism, and make their functionality even more efficient. Psychologists note that information remains in the memory of a person 10% of what he hears, 50% of what he sees, and 90% of what he does himself. The great support of ICT in this area is in providing the learner with a powerful information bank during his personal research (Internet, e-books, tests and assignments, etc.).

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THE ROLE OF COMPUTER SCIENCE IN THE DEVELOPMENT OF MATHEMATICAL MODELING SKILLS IN 9TH GRADE STUDENTS

Gardashova Z.
Azerbaijan State Pedagogical University, doktorant,
teacher of the Department of Mathematics and its Teaching Technology,
Faculty of Mathematics, Baku
DOI: 10.5281/zenodo.18081788

Abstract

The digitalization of modern education makes the integration of mathematical modeling with informatics relevant in the teaching of algebra in the 9th grade. The purpose of the study is to determine the methodological role of informatics in the formation of mathematical modeling skills in students and to substantiate the advantages of the integrative teaching approach. The essence and stages of mathematical modeling are explained in the content of the article, and the relationship of algebraic sequences with informatics structures is analyzed. The study applies a methodological analysis based on comparative analysis, modeling, and the use of digital learning environments.

The results show that the algorithmic approaches of informatics and the principles of data structuring have a significant impact on students' deeper assimilation of mathematical concepts, strengthening of analytical thinking, and the development of the ability to express real situations with mathematical models.

Keywords: mathematical modeling, computer science integration, algebra teaching, algorithmic thinking, numerical sequences, digital learning.

Introduction

In the modern era, the digitalization of education puts forward new requirements for the teaching of mathematics, especially algebra. The rapid development of digital technologies makes it necessary to form students' information processing, algorithmic thinking, analytical analysis, and modeling skills. The study of algebra topics in the 9th-grade, especially the mastery of concepts such as functions, equations, and numerical sequences, requires students to think logically and build mathematical models of real situations. The integration of this process with the subject of computer science allows for a more efficient, visual, and application-oriented understanding of mathematical modeling. In this regard, the role of computer science in the development of mathematical modeling skills is currently one of the most relevant directions in the pedagogical field.

The purpose of the study is to determine the methodological potential of computer science and digital tools in the formation of mathematical modeling skills in 9th-grade students and to substantiate the integrative teaching approach. To achieve this goal, the concept of mathematical modeling, its stages, and didactic features are analyzed, as well as the logical, algorithmic, and visual connections between computer science and algebra are investigated.

Comparative analysis, literature review, modeling, and methodological analysis based on the application of collaborative learning approaches and digital programs (Graph, GeoGebra, Python, etc.) are used as research methods. These methods create conditions for evaluating new learning opportunities arising at the intersection of mathematical and computer science thinking.

The essence, stages, and application features of mathematical modeling in teaching

Mathematical modeling is one of the main components of modern mathematics education and is characterized by expressing real-life processes and phenomena in mathematical language and analyzing them on a simplified model (Blum et al., 2007). This process not only teaches students to master mathematical knowledge but also teaches them to identify relationships between phenomena, predict outcomes, and evaluate the interaction of various variables (NCTM, 2000). In particular, modeling skills at the 9th grade level provide a deep understanding of algebraic topics and have a significant impact on the structuring of the student's mathematical thinking (OECD, 2019).

The mathematical modeling process consists of several sequential stages, and these stages systematically develop the student's ability to conduct independent analysis (Stillman & Brown, 2012):

1. Understanding the problem. At this stage, the student understands the essence of the presented real situation, accurately analyzes the problem, and determines its purpose and limitations. A correct understanding of the essence of the problem directly determines the quality of the mathematical model (Kaiser & Sriraman, 2006).

2. Building a mathematical model. The selection of features, variables, and parameters, and the determination of functional or logical relationships between them, form the basis of this stage. Equations, functions, graphs, sequences, and sometimes algorithmic structures are used in building the model (Blum et al., 2007). Grade 9 algebra topics create wide application opportunities at this stage.

3. Model solution. At this stage, operations are performed on the mathematical model built, equations are solved, functions are analyzed, and results are obtained. This process can be carried out using both symbolic, graphical, and informatics approaches (for example, using Python or Graph programs) (Yerushalmy, 2006).

4. Interpretation of results. The obtained mathematical results are compared with the real situation, their meaning is interpreted, and their accuracy is checked. At this stage, students evaluate the correspondence between the “mathematical result” and the “real result” and determine the adequacy of the model (English, 2006).

The didactic properties of mathematical modeling make it one of the most effective teaching strategies in

mathematics teaching. Modeling develops students' critical, analytical, and creative thinking, creates conditions for the formation of an active learning environment, and also allows for the establishment of connections between different fields of knowledge (Kaiser & Sriraman, 2006). Students' modeling skills strengthen both their mathematical logic and the problem-solving and decision-making competencies required in their future activities.

This process is of particular importance at the 9th-grade level. At this stage, students learn systems of equations, quadratic functions, numerical sequences, and other important algebraic concepts. The application of these concepts within the framework of mathematical modeling teaches students to build a bridge between real life and mathematical theory, formalize situations, and make decisions based on mathematical results (Stillman & Brown, 2012). Thus, modeling both provides a functional application of mathematical knowledge and creates a basis for natural integration with computer science (OECD, 2019).

The role of informatics in the development of mathematical modeling skills

In the modern educational environment, informatics plays a key role in the formation of students' skills in algorithmic thinking, logical sequence, information structuring, and process modeling (Grover & Pea, 2013). These skills directly affect the more systematic and deep mastery of all stages of mathematical modeling. Informatics allows students to create digital representations of abstract mathematical objects and test models in various software environments, which makes the teaching of algebraic topics more visual and application-oriented.

The impact of informatics on mathematical modeling is primarily related to the formation of algorithmic thinking. The algorithmic approach facilitates the identification of variables, the definition of relationships, and the step-by-step structuring of the solution when building a mathematical model (Wing, 2006). In the 9th grade, topics such as equations, functions, and sequences are fully consistent with the algorithmic description and allow the student to understand the sequential logic of a mathematical problem.

The second important aspect is visualization capabilities. In the computer science environment, graphic representations, dynamic models, simulations, and interactive presentations more clearly show the structure of a mathematical model. For example, various studies have proven that graphic models built using programs such as Graph and GeoGebra strengthen mathematical thinking (Hohenwarter & Jones, 2007). This approach provides a visual perception of the solution of equations, the properties of functions, and the interaction of variables.

The third direction is related to conducting digital experiments. By changing the values of various variables in programming environments, the dynamism of the model results is observed. Such experiments allow students to discover mathematical regularities, put forward hypotheses, and test them (Grover & Pea, 2013). As a result, the student more easily understands how to express real situations in mathematical language and conduct analysis using the model.

In addition, informatics also develops students' ability to structure and process information, which is important for all stages of mathematical modeling. Activities such as sorting data into types, determining the relationship between variables, and interpreting results are central components of both informatics and mathematics.

Consequently, integration with informatics has a multifaceted impact on the development of mathematical modeling skills: it systematizes mathematical thinking, facilitates the construction and understanding of models, makes teaching more interactive and application-oriented, and strengthens students' analytical and decision-making skills. In particular, at the IX grade level, this integration creates an important methodological potential for the development of both mathematical and digital literacy of students.

Linking numerical sequences with informatics models

In the 9th-grade "Mathematics" textbook, the topic of numerical sequences is built on basic concepts such as numerical series, geometric series, their nth term, and the sum of the first n terms (Gahramanova, Karimov & Huseynov, 2019). These topics are fully consistent with the algorithmic structures of informatics in terms of the definition of a sequence, that is, the connection of each term with a previous term or several previous terms based on a certain regularity. It is this consistency that justifies the connection of sequences with informatics models both methodologically and in terms of content.

The basic algorithmic structures used in computer science lessons - the concept of a variable, the repetition (cycle) operator, the conditional operator, and the recursive representation - allow us to model the mathematical structure of sequences. For example, the recurrent definition for a numerical sequence $a_n = a_{n-1} + d$ is naturally realized in computer science with the cycle operator. In this regard, the sequence can be presented to the student both as a mathematical equation and as an algorithm.

Mathematical description:

$a_1 = 5, \quad a_n = a_{n-1} + 3$

Algorithmic description ***(Python pseudo-code):***

```
go

a = 5
for i in range(1, N+1):
    print(i, a)
    a = a + 3
```

Introducing this parallelism helps students develop two important skills:

first, structuring the order in which a sequence is constructed; second, understanding the dynamic relationship between variables (Cormen et al., 2009).

Let's look at an example with both a mathematical and an algorithmic description based on the formula $a_n = a_1 + (n-1)d$ for the *n*-th term of a numerical series.

Mathematical description.

Example: If the sequence contains $a_1 = 4,\ d = 3$, find a_{10}.

$$a_{10} = a_1 + (10-1)d$$

Solution: $a_{10} = 4 + 9 \cdot 3$

$$a_{10} = 4 + 27 = 31$$

Answer: $a_{10} = 31.$

Let's write an algorithmic description for the given example. Goal: To calculate the 10th term of the sequence, starting from the fourth term.

```
python

a = 4
d = 3

for i in range(2, 11):
    a = a + d

print(a)
```

Result: output: 31.

Geometric sequences are modeled in a similar way; the recurrent definition for a geometric sequence is $a_n = a_{n-1} \cdot q$ which is implemented in programming by looping and multiplying.

Students can observe the rate of increase/decrease of a sequence by trying different values of the *q* factor in Python, Scratch, or block-based environments, which reinforces mathematical concepts visually and empirically (Hohenwarter & Jones, 2007).

In addition, the principles of computer science data structuring - storing variables, creating lists, indexing sequential elements allow for the representation of a numerical sequence as a "set of terms." This approach allows for the solution of tasks set in the textbook (calculating the limit, the sum of the first n terms, etc.) together with computer science models and teaches the student to interpret both mathematical and practical results (Gahramanova, Karimov & Huseynov, 2020).

Thus, the integrated teaching of numerical sequences between mathematics and computer science allows students to master the process of constructing, changing, and analyzing sequences in a more clear, visual, and technologically based way; this connection makes a significant contribution to the development of both mathematical modeling and algorithmic thinking skills (Grover & Pea, 2013; Cormen et al., 2009; Gahramanova, Karimov & Huseynov, 2020).

Numerical sequences (and mathematical models in general) are very important not only for numerical or symbolic analysis, but also for the formation of algorithmic thinking in computer science and programming. The key point here is the interaction of mathematical representation and algorithmic representation.

1. Mathematical representation: The *nth* term or sum of a numerical sequence is expressed as a formula. For example, $a_n = a_1 + (n-1)d$. This shows the regularity of the sequence.

2. Algorithmic representation: The same sequence can be calculated and automated using a programming language. For example, with Python:

```
python

a1 = 2
d = 3
n = 10
an = a1 + (n-1)*d
print("10-cu üzv:", an)
```

This teaches the student or programmer to calculate, analyze, and visualize sequences.

Algorithmic representation of numerical sequences and mathematical models through informatics develops logical thinking, problem-solving solving and decision-making skills in students, and also allows for the practical application of mathematical knowledge in real-life and social situations.

- ***Automation of complex problems:*** A person can quickly calculate large sequences and sums that a person would have to calculate manually through a program.
- ***Development of analytical thinking:*** Converting a mathematical formula into algorithmic steps develops the student's logical thinking and planning skills.
- ***Life applications:*** Sequences are implemented algorithmically in financial calculations (for example, monthly payments, interest calculations), physics, and statistical models.
- ***Connection with informatics:*** Mathematical model → algorithmic model → programming → analysis of results. This chain strengthens the integrative approach in teaching.

That is, the algorithmic description of numerical sequences is not only for programming, but also allows the student to apply mathematical thinking to the practical world.

The role of informatics in the development of mathematical modeling skills in students is indispensable. For example, students can calculate their monthly savings plan, water or electricity consumption through numerical sequences and functions using Python or other programs. This teaches not only theoretical calculations, but also algorithmic analysis and visual display of results. Such an approach strengthens students' logical thinking, problem-solving, and decision-making skills. As a result, mathematical education integrated with informatics turns students into individuals who think independently and make decisions based on mathematical grounds in the economic, environmental, and social situations they encounter in real life.

Conclusion

The role of informatics in the development of mathematical modeling skills in grade IX is indispensable. Through informatics, students gain the ability to solve mathematical problems not only at the theoretical level, but also at the algorithmic and practical level. Programming environments and algorithmic analysis tools allow students to visually demonstrate complex sequences, functions, and algebraic structures, analyze

them, and predict results. This process also accelerates the formation of logical thinking, planning, and problem-solving skills. As a result, mathematical education integrated with informatics creates conditions for the development of functional skills in students in both mathematical and computer science, turning them into individuals who can think independently and make decisions in real-life and social situations.

Suggestions

The integration of mathematics and computer science subjects should be carried out systematically. Especially in the 9th grade, algebraic topics — functions, equations, and numerical sequences - should be taught in parallel with the algorithmic structures of computer science, and students should be shown the general logical connections of both subjects.

Digital tasks should be increased to develop mathematical modeling skills. Students should be given the opportunity to build a mathematical model of real-life situations and describe it algorithmically, and practical activities on data processing, working with variables, and generating sequences should be expanded.

The use of interactive and visual environments in teaching algebraic subjects should be strengthened. Simple programming environments that demonstrate graphics, conditional, and periodic structures should be included in the teaching process, and students should master abstract concepts through visual models.

Joint methodological training should be organized for teachers. Joint seminars, open lessons and exchange of experience of mathematics and computer science teachers would help to form a unified approach to integrative teaching.

Measurement tools should be developed that assess students' mathematical and algorithmic thinking. Assessment should be based not only on the result, but also on the skills of building models, analyzing problems, designing algorithms, and interpreting results.

More emphasis should be placed on modeling real-life problems. Data analysis on energy consumption, budget planning, production growth, environmental indicators, and other socio-economic processes strengthens the development of both mathematical and informatics skills.

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A COMPARATIVE ANALYSIS OF EDUCATIONAL GOVERNANCE SYSTEMS IN THE UNITED STATES, CHINA, AND AZERBAIJAN

Guliyeva P.
Master's student in Azerbaijan State Pedagogical University
DOI: 10.5281/zenodo.18081798

Abstract

This article presents a comparative analysis of the educational governance systems in the United States, China, and Azerbaijan, focusing on the management structures, policy implementation, and pedagogical approaches of each country. Education systems worldwide are shaped by diverse political, social, economic, and cultural factors, leading to different governance models that influence the delivery and quality of education. The U.S. education system is decentralized, with states and local governments influencing policy and school management, while China and Azerbaijan have centralized systems, with the national government overseeing policies, curricula, and teacher management. The article compares these systems, highlighting their strengths and weaknesses, and underscores the importance of comparative studies for improving global education policies and practices.

Keywords: Educational systems, governance models, decentralization vs centralization, student participation, education management, global education comparisons.

Comparative study of educational institutions is one of the important directions of pedagogical science, and research conducted in this field serves to identify similarities and differences between the educational systems of different countries. Comparative analysis is important in terms of revealing existing problems in the field of education, studying innovative approaches and applying effective practices. This process also creates scientific foundations for improving the national education model and making strategic decisions based on international experience.

Education systems around the world are influenced by the cultural, economic, political and historical factors of each country, resulting in different approaches to educational governance. Each system is shaped by its own local needs, but the overall goal reflects a global effort to optimize educational processes and learning outcomes for individuals and societies. Its main goal is to create effective structures and practices that facilitate the delivery of quality education. The way countries organize and manage their educational institutions, and the policies that support these structures, reveal both global common goals and local specificities. This comparative analysis examines the different educational governance systems around the world, considering the balance between centralized and decentralized models, the role of the public and private sectors, and the impact of technological advances.

The application of comparative frameworks to the analysis of educational governance plays a crucial role in systematically assessing and understanding the diversity and effectiveness of education systems around the world. These frameworks allow for comparisons of educational practices across countries according to specific criteria. The comparative framework includes differences in student achievement, the efficiency of resource allocation, governance structures and the cultural relevance of curricula. By comparing these indicators across countries, stakeholders can identify patterns of performance, potential areas for reform and develop strategies that respond to both local and international educational needs. Furthermore, the use of a comparative approach helps to identify inequalities within and between countries, provides a basis for discussion and thus contributes to ensuring equitable and quality educational opportunities for all students.

Comparison of education systems always involves both the concepts of "difference" and "similarity". On the one hand, education systems around the world can demonstrate diversity, and on the other hand, they can also demonstrate similarity. The relationship between these two concepts should not be contradictory, but rather complementary.

The educational governance landscape in the United States is a unique blend of federal, state, and local governance that reflects the country's sociopolitical diversity. U.S. education policy is decentralized, granting significant autonomy to state and local governments. The federal government sets broad standards and provides funding to promote civil rights in education and equitable access across socioeconomic lines. Thus, the U.S. educational governance system embodies a complex interplay of local autonomy, federal leadership, and responsive policies aimed at meeting diverse educational needs[1]. China's education system is highly centralized, with the government playing a key role in setting curricula, policies, and educational standards. The Ministry of Education oversees the entire education system, and its policies affect everything from school infrastructure to teacher training. Several major reforms have transformed China's education landscape in recent years. The Chinese government has historically maintained tight control over its education system. One of the key features of China's education structure is centralization, where policies, curricula, and examinations are set at the national level. This approach helps ensure uniform educational standards across the country. Local governments implement these policies, but have limited autonomy to make changes to curricula and pedagogical methods.[2]

If we compare the educational concepts between China and the United States, we can see that the modern education of the West has formed its own concept. This concept is reflected in the fact that students are the main entity in the classroom. In the US classroom, teachers always try to involve students in group discussions and cooperation, and everyone's opinions can be expressed

openly. Teachers encourage students to express their opinions and require them to clearly define their beliefs, which develops students' confidence and self-confidence. In China, under the influence of the traditional ideology of "respecting the teacher and appreciating the path", the classroom atmosphere is usually serious. Teachers and students pay attention to classroom order, respect for teachers, and not to insult them. Therefore, Chinese students often have a sense of respect and reverence for their teachers, and generally do not dare to question the subjects they teach. Similarly, traditional Chinese education pays special attention to the selection and management of teachers, but very little attention is paid to their enthusiasm and initiative in the teaching process. This is because teachers' leadership in the teaching process "It causes students to only passively accept the knowledge taught by teachers, which prevents students from learning and increasing their interests.[3]

According to the educational concept adopted in Azerbaijan in recent years, the teaching process is organized on the basis of rules that are more interactive, student-centered and meet modern requirements. This teaching process is aimed at actively involving students in the lesson, developing their independent thinking and problem-solving skills. Students are not only listeners in the classroom, but also participants in discussions and active members of group work. This approach ensures that students master their knowledge more deeply and increase their critical thinking skills.

The management of education systems depends mainly on the social, political and economic structures and education laws of each country. The forms, objectives and implementation mechanisms of education systems in different countries differ from each other. For example: The Azerbaijani education system is centrally managed. Thus, the Ministry of Education is responsible for the organization, control and development of all levels of education, the preparation of curricula, the recruitment of teachers, and the appointment of school principals. In the United States, the education system is decentralized. The management of education is mainly carried out by states and local school districts. The federal government only determines general education policy and implements financing. In the United States, curriculum, assessment and school management vary by state and school. Each state determines its own education laws and curricula. The Chinese education system is highly centralized, but some regions and universities are given a certain degree of autonomy. The Ministry of Education determines the curriculum, examination system and quality of education for the entire country. Education management is carried out by the Central People's Government. School principals are sometimes appointed with the approval of local party bodies.

When comparing the education systems of these countries, we can conclude that Azerbaijan and China use a more centralized management model, while in the United States, education management is carried out at the local level, which creates opportunities for personalized education.

The Chinese education system includes central, provincial, municipal and district-level structures responsible for education management. The Ministry of Education is responsible for formulating strategies, policies and plans for educational reform and development; formulating relevant rules and regulations and supervising their implementation. School principals are appointed by regional education management bodies. At least 10 years of teaching experience is required to become a principal.

Although the requirements for becoming a school principal in the Chinese education system vary by province or region, these requirements generally include having at least ten years of teaching experience, being a Chinese citizen living within the country's borders, and having the ability to educate ideologically, politically, and morally. The candidate's party membership and experience are also important in the selection of candidates. To become a qualified candidate, a "certificate of suitability for school principal" is required. The requirements for obtaining this certificate are a written examination, an academic qualification certificate, and work experience as a teacher. In addition to these requirements, the candidate must also have received an invitation to apply for the vacancy. In Shanghai, school principals receive leadership training for six months after being appointed. This training is conducted by universities and experts in education, management, and psychology and consists of six topics within the framework of professional standards for principals. These topics are school planning, internal management, school culture, instructional development, teacher training, and adaptation to the external environment. The program, which consists of group training, individual research projects, field trips, and mentoring of new principals by experienced principals, is held once a week "It is carried out once.

In the United States, the education system is more locally managed, allowing for flexibility to adapt to individual educational needs and giving states autonomy. China has a centralized education system, where educational policies and curricula are determined by the central government and provinces only perform an implementation function. Azerbaijan, on the other hand, has a more centralized approach, with the Ministry of Education managing all levels of education, developing curricula, and centralizing issues such as teacher recruitment. These different approaches reflect the unique characteristics and priorities of each country's education system.

Comparative study of educational institutions is one of the main directions of research in the field of education, and this process leads to many important results:

The most significant differences between the education systems of different countries are observed in the management structures and implementation of educational policies. Azerbaijan and China have highly centralized systems of educational management, where the state, especially the Ministry of Education, plays a key role. In the United States, a decentralized approach prevails, where states and local school districts implement

educational policies, which allows each region to develop educational systems that are appropriate to its own characteristics.

Comparative study of education systems allows to identify the strengths and weaknesses of each country's educational management and teaching methodology, to ensure the successful implementation of modern educational reforms, as well as to adapt international experience and strategic decisions to the local context. The differences between Azerbaijan, China and the United States show how education policy is shaped in a way that responds to local and global needs. Through comparative approaches, it is possible to create more inclusive, equitable and high-quality educational opportunities in the field of education.

Currently, educational leadership is considered a task that every teacher can perform, and it is thought that a good teacher will make a good administrator. However, educational leadership is a field that requires specialization as much as teaching. It is not realistic to expect people who have not received special training in this field to succeed in educational leadership, even if they are teachers.

Comparative study of educational institutions creates conditions for effective decision-making in education, adoption of best practices, and improvement of national education policy.

At the same time, these comparisons help identify inequalities in education systems and make strategic decisions aimed at providing more equitable and quality opportunities in the field of education. Comparative analyses pave the way for the development of effective education policies and strategies that respond to both local and international educational needs. This process facilitates the study and application of best practices in the field of education and provides each country with a scientific basis for developing its own education system.

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MATRIX FOR DEVELOPING NETWORK COMMUNICATIVE CULTURE AND NETWORK ETIQUETTE

Tanatova A.
Associate Professor, Department of Pedagogy,
Candidate of Pedagogical Sciences
Abai Kazakh National Pedagogical University
DOI: 10.5281/zenodo.18081813

Abstract

The article examines the conditions and factors influencing the formation of network communication culture and digital etiquette among university instructors and students in the context of rapid digital transformation in education. The paper substantiates the need for purposeful development of digital skills among both teachers and learners, as the growing use of digital technologies, online formats, and virtual learning environments requires a new level of interaction culture and adherence to norms of digital conduct. The proposed matrix of developmental levels of network communication culture and digital etiquette presents an interconnected set of competencies that ensure a progressive transition from the reproductive to the productive and ultimately to the creative level of their formation. Each level is characterized by a specific range of knowledge, skills, and modes of activity required for professionally responsible and ethical participation in the digital educational environment.

Keywords: network communication culture, digital etiquette, digital literacy skills, online collaboration, reflexive thinking, critical thinking skills, virtual interaction, higher education environment, digital competencies, educational digitalization.

Introduction

The XXI-st century is characterized by large-scale and rapid transformations driven by the intensive development of digital technologies. Robotics, 3D printing technologies, artificial intelligence systems, virtual interaction environments, and modern bio- and neurotechnologies are consistently integrated into the educational space, directly influencing the transformation of the content, mechanisms, and forms of educational activities.

Information and communication technologies are becoming a system-forming component of the educational environment, leading to its reorganization and orientation toward forming a digital ecosystem in higher education institutions. The higher education system faces the task of adapting to the new conditions of digital transformation, which requires rethinking traditional approaches to teaching and interaction among participants in the educational process.

In the context of the dominance of digital technologies, educational practice must respond to modern challenges while adhering to the norms, principles, and regulations of teaching, learning, and professional communication in the online environment. University faculty, alongside using traditional offline teaching forms, must demonstrate a high level of proficiency with digital tools and implement online and blended learning formats. At the same time, there is a growing need for educators to observe norms of digital culture and digital etiquette, as well as to purposefully develop students' skills in network interaction. Faculty who possess these competencies and integrate them into their professional activities exhibit higher competitiveness due to their developed network communicative culture and adherence to digital etiquette.

Contexte

In modern conditions, teachers and students need to possess digital skills. Therefore, it is essential to form digital culture and digital etiquette among both students and teachers in online spaces. It is important to teach adherence to digital etiquette norms, development of skills for effective use of new digital technologies and educational resources, and formation of a culture of reflexive consumption of digital content and correct behavior in virtual environments.

The faculty of Abai Kazakh National Pedagogical University has been conducting research from 2023 to 2025 on the topic "Customization of the system for forming network communicative culture and digital etiquette of faculty and students in the university's 'online community'" (headed by U.M. Abdigaparova).

As part of the research, A.D. Tanatova and Sh.Zh. Kolumbaeva also presented a matrix demonstrating the key skills of faculty necessary to achieve a high level of network communicative culture and digital etiquette. This matrix shows the interrelation of the development levels of network communicative culture (hereinafter - NCC) and digital etiquette (hereinafter - DE) based on the presence of specific skills.

The matrix for forming network communicative culture (hereinafter - NCC) and digital etiquette (hereinafter - DE) represents a systemic model that includes an interconnected set of skills ensuring the progressive development of these competencies among faculty. These skills serve as the basis for constructing a modern, technologically equipped educational space that contributes not only to achieving academic outcomes but also to the formation of ethically oriented and responsible participants in digital interaction.

Methodologie

The transition from the reproductive to the creative level of NCC and DE development implies a conscious understanding by the faculty of the importance of these competencies, necessary for effective pedagogical interaction in the context of digitalization.

The matrix identifies three levels of NCC and DE development:

- the reproductive level is based on the integration of subject-specific, pedagogical, and technological knowledge.

- the productive level involves mastery of critical thinking skills, reflection, and communicative activities, including digital communication.

- the creative level is characterized by developed digital literacy, digital culture and etiquette competencies, as well as the ability to collaborate effectively in virtual space. The corresponding indicators of the levels are presented in Table 1.

Table 1.

Levels of Development of Network Communicative Culture and Digital Etiquette Skills

Reproductive Level of NCC and DE		
Component	**Role**	**Functions**
Subject Knowledge	Helps teachers confidently and qualitatively transmit educational (subject) information (material), providing students with a basis for developing their functional literacy.	Enriches the content of subject communication, contributes to the formation of critical thinking and deep understanding of the topic (subject, discipline) in students.
Pedagogical Knowledge	Helps teachers consciously understand, integrate, adapt, and apply theoretical, practical, and managerial aspects of constructive teaching and learning	Constructs a holistic pedagogical process, develops respectful and constructive interaction between the teacher and students, forms an educational collaborative atmosphere, and stimulates the teacher's professional development
Technological Knowledge	Helps teachers consciously use new technologies and modern tools in education and student learning.	Allows creation of interactive, multimedia educational environments and implementation of interactive learning platforms and technologies.
Productive Level of NCC and DE		
Component	**Role**	**Functions**
Reflection Skills	Helps teachers constructively analyze their own teaching and learning practice, identifying and evaluating its strengths and weaknesses.	Creates an atmosphere of openness and readiness for constructive changes in the educational process, improving teaching and learning quality, and contributing to the teacher's personal and professional development
Critical Thinking Skills	Helps teachers consciously observe, objectively analyze, critically evaluate, and effectively use information in the educational process	Forms in teachers and students the ability for constructive analysis and justification of their own viewpoints based on reliable facts and arguments.
Communication Skills	Helps teachers realize the importance of verbal and non-verbal communication skills necessary for effective interaction with subjects of the pedagogical process (teachers, students)	Creates a safe atmosphere of trust and collaboration necessary for productive educational processes, simplifies communication and joint work, making learning more accessible and engaging.
Digital Communication Skills	Helps teachers consciously apply modern digital communication technologies in the educational process.	Allows creation of networks (chats) of contacts and collaboration, forming cultural and ethical norms of communication in educational online environments
Creative Level of NCC and DE		
Component	**Role**	**Functions**
Digital Literacy and Competencies Skills	Helps teachers consciously and optimally effectively use digital resources and platforms	Ensures successful use of digital technologies and tools in the educational process and contributes to reducing digital inequality
Digital Culture and Etiquette Skills	Helps teachers realize the importance of adhering to the code (norms) of behavior in digital educational spaces	Contributes to creating a safe and respectful educational online environment where all communication participants feel comfortable and secure
Collaborative Skills in Virtual Spaces	Helps teachers consciously build effective and safe interpersonal relationships.	Forms a collaborative environment, develops teamwork skills, teaches working and jointly designing educational initiatives in diverse environments, and develops network communicative culture

The matrix makes it possible to conceptualize the formation of network communication culture and digital etiquette as an integrated and systemic developmental model aimed at enhancing teachers' professional competence and students' digital responsibility.

Conclusions

It should be emphasized that the development of digital competencies—from communication ethics and culture to forming reflective and critical thinking—is one of the key tasks of modern higher education. To enhance the level of NCC and DE development, massive open online courses (MOOCs) have been developed, targeted at faculty and students of higher education institutions.

Forming network communicative culture and digital etiquette for teachers and students in "online communities" is not just "culture" and "etiquette," but a synthesis of concepts such as "safety," "collaboration," "critical thinking," "cooperation," "customization," as well as high professional mastery of the teacher in effective teaching and learning in digital spaces. Thus, customization of the system for forming network communicative culture and digital etiquette in universities is a key factor for successfully integrating online platforms into the educational process, creating a comfortable and productive educational environment for students' successful adaptation to new educational technologies, communication, and rules of ethical behavior, including in network communities.

Thus, the customization and institutionalization of the system for forming network communicative culture and digital etiquette in universities serve as a strategic condition for the successful integration of online platforms into the educational process. This, in turn, ensures the creation of a comfortable, technologically advanced, and productive educational environment, while also promoting students' effective adaptation to modern digital technologies, communication formats, and norms of ethical behavior, including rules of network interaction in professional and academic digital communities.

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PHARMACEUTICAL SCIENCES

RETROSPECTIVE ANALYSIS OF MEDICAL RECORDS OF INPATIENTS WITH GASTRITIS

Suyunov N.
Doctor of Sciences in Pharmaceutics, professor, Head of Department of pharmaceutical organization of the Tashkent Pharmaceutical Institute
ORCID: 0000-0002-2712-958X
Ibragimova G.
basic doctoral student of the Department of pharmaceutical organization of the Tashkent Pharmaceutical Institute
ORCID: 0009-0007-8835-1110
DOI: 10.5281/zenodo.18081833

Abstract

The research was conducted based on the data of patients treated in the gastroenterology department of the Multidisciplinary Clinic of Tashkent State Medical University. The study included a retrospective analysis of the medical records of inpatients diagnosed with gastritis, as well as the examination and processing of statistical indicators, presenting pharmacoeconomic frequency-based results related to the use of medications.

According to the findings, in the treatment of gastritis, proton pump inhibitors -omeprazole, rabeprazole, and pantoprazole - were used with the highest frequency, accounting for a significant share of medication-related expenditures. The obtained results provide a basis for optimizing the timely supply of medicines to patients, improving the quality of inpatient treatment, and minimizing overall healthcare costs.

Keywords: gastritis, disease, medications, medical records, retrospective analysis, pharmacoeconomic frequency analysis.

Introduction. A number of retrospective and pharmacoeconomic frequency-based studies related to gastritis and its treatment have been conducted worldwide. In particular, these studies present the following findings.

Gastritis is an inflammation of the gastric mucosa and represents a disease characterized by substantial heterogeneity in its clinical presentation, etiology, and histopathological features. Recent analyses indicate that in 2021 the global number of patients with gastritis and duodenitis reached approximately 27.2 million, with an age-standardized incidence rate (ASIR – Age-standardized incidence rates) of 323.2 per 100,000 population. [4]. According to another source, in 2019 the global number of patients with gastritis and duodenitis reached 31 million, which represents an increase of 12 million compared to 19 million cases reported in 1990. Notably, data from the Global Burden of Diseases (GBD) study for the period 1990–2019 indicate that the Disability-Adjusted Life Years (DALY) associated with gastritis – reflecting disability and years of life lost due to premature mortality – decreased from 48.1 to 34.8 per 100,000 population. However, despite this reduction, the total number of affected patients has continued to rise [3]. According to the 2021 estimates of the Global Burden of Diseases study, the number of patients with gastritis was higher among women than men, and the incidence rate increased with age. Statistical data indicate that gastritis typically begins to appear in middle age, with the highest prevalence observed in individuals aged 40–59 years [4]. Studies conducted in Uzbekistan indicate that approximately 80% of the population is infected with Helicobacter pylori [2]. Among the main treatment approaches for Helicobacter pylori infection, regimens containing amoxicillin and furazolidone have demonstrated the highest eradication efficacy in previously untreated patients. The date of treatment, the patient's age, the selected antibiotic regimen, and the duration of therapy have been identified as risk factors contributing to unsuccessful *H. pylori* eradication. In addition, it has been observed that the results of the post-eradication Urease Breath Test (UBT) tend to cluster around the established cut off value in many cases [5]. The study included medical records of a total of 186 patients. The overall eradication success rate was 77.4%. The results indicated that the reduction in eradication efficacy was significantly associated with the presence of diabetes and smoking status, with statistical significance values of $p < 0.001$ and $p < 0.004$, respectively. These findings suggest that the standard triple therapy for *Helicobacter pylori* eradication demonstrates lower efficacy compared to the optimal standards recommended in the literature and clinical guidelines. Given the declining effectiveness of this treatment worldwide, the use of alternative regimens and protocols as first-line therapy may be necessary. Further studies are required to assess treatment efficacy across different regional settings [1]. In Uzbekistan, 21 medications with internationally recognized non-proprietary names used for the treatment of gastritis have been registered under a total of 200 trade names. Analysis of these drugs by manufacturer country shows that 55% are from foreign countries, 37.5% are produced by local pharmaceutical companies, and 7.5% are registered by countries of the Commonwealth of Independent States (CIS) [6]. The above-mentioned studies have addressed gastritis, its prevalence, treatment approaches, and included retrospective analyses of the medical records of hospitalized patients, as well as recommendations for the use of specific medications during therapy. These studies underscore the relevance and necessity of conducting similar research in the context of Uzbekistan, both to retrospectively analyze the medications used for gastritis treatment and to perform

pharmacoeconomic frequency-based analyses. The objective of this study was to conduct a retrospective analysis of the medical records of hospitalized patients with gastritis and to perform a pharmacoeconomic frequency-based analysis of the medications used in their treatment.

Methods. In the study were analyzed medical cards of inpatients treated for gastritis in the Gastroenterology Department of the Multidisciplinary Clinic of Tashkent State Medical University from 2018 to May 2025. The research employed methods such as retrospective analysis, comparison, grouping, statistical processing, and pharmacoeconomic frequency-based analysis. Among the pharmacoeconomic methods, the frequency-based analysis is a type of quantitative assessment that reflects the recommendation or non-recommendation of specific medications solely based on evidence of their actual use in patient treatment.

Results and Discussions. In our study, analyses were conducted on the age, sex, and frequency of medication use among patients with gastritis. In the first stage of the research were analyzed the number of patients treated for gastritis and their sex distribution at the Multidisciplinary Clinic of Tashkent State Medical University. The results of this analysis are presented in Figure 1.

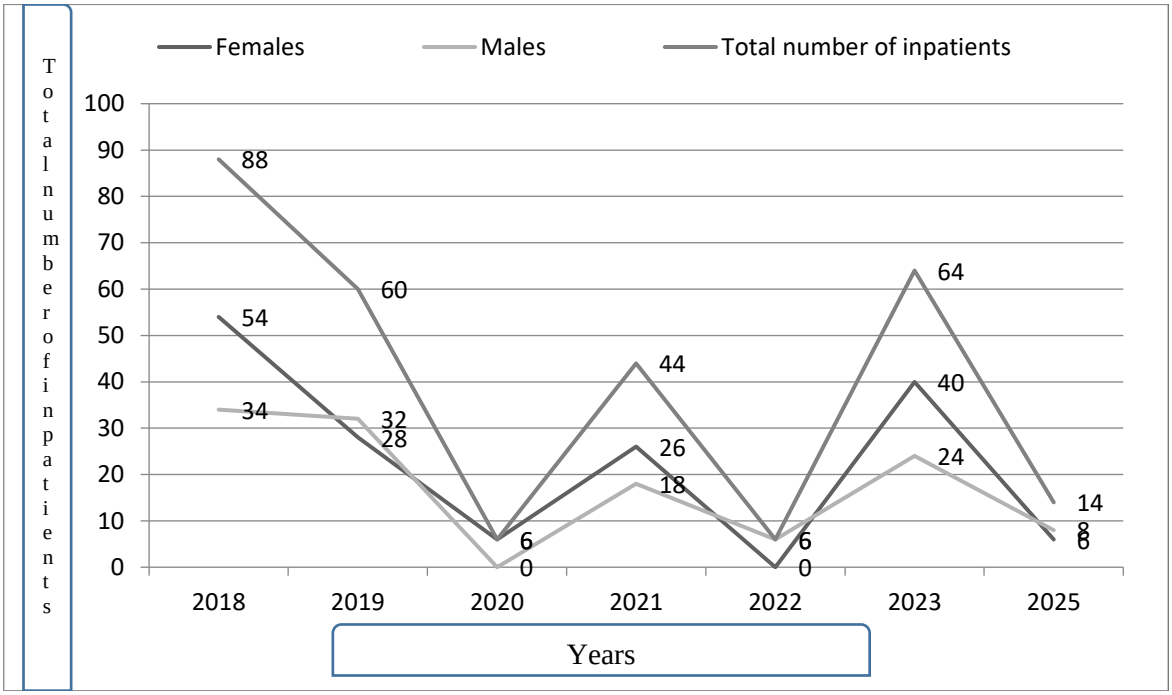

Figure 1. Analysis of inpatients with gastritis by gender

The study analyzed the distribution of patients by gender. It was found that the number of female patients was higher than that of male patients. In 2018, the total number of treated patients was 88, of which 38.64% were men and 61.36% were women.

Analysis of patient data from 2018 to 2025 revealed that the total number of treated patients was highest in 2018, followed by a gradual decrease during 2019–2021. The lowest patient count was observed in 2022. Notably, in 2020, the clinic's gastroenterology department suspended operations due to the COVID-19 pandemic. In the next stage of our research, an analysis of patients by age was conducted (Figure 2). Patients were primarily treated between the ages of 18–90. The highest morbidity was determined to correspond to patients aged 20–29. Among the patients treated at the clinic, those in the 20-39 and 60-69 age ranges particularly predominate. Accordingly, in 2018, patients aged 20-29 were treated in relatively larger numbers; in 2019, those aged 30-39; and in 2023, those aged 60-69.

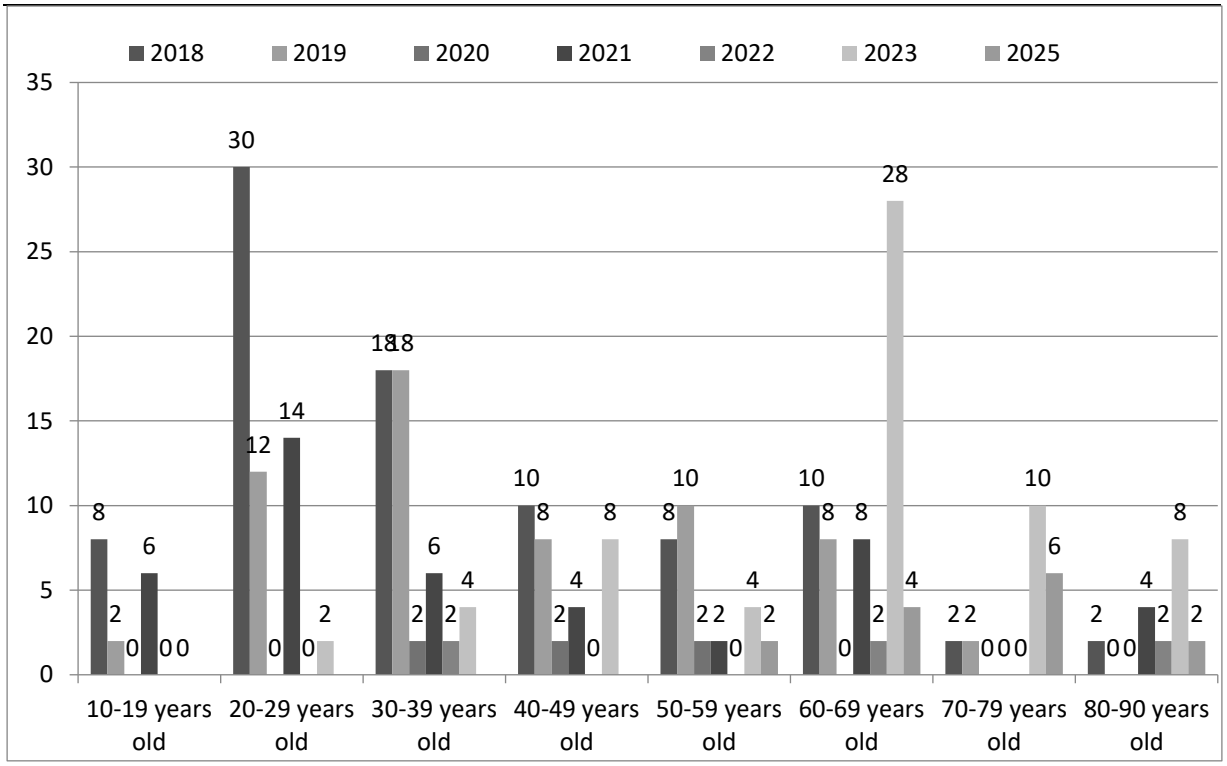

Figure 2. Age-based analysis of patients with gastritis

The age distribution of patients was analyzed, and the hypothesis test revealed that the mean number of patients differed significantly from zero, $t(7) = 5.49$, $p < 0.05$. These results indicate that in the hospital, a higher number of patients was observed in the older age group, particularly among those aged 60–69 years, and show a positive deviation of the overall mean from zero. This supports the presence of the studied condition within the population.

Analysis of the demographics of patients treated at the clinic revealed that patients residing in rural areas outnumbered those living in urban areas. The results of this analysis are presented in Figure 3. Between 2018 and 2025, a total of 182 patients (64.54%) from rural areas and 100 patients (35.46%) from urban areas were treated at the clinic.

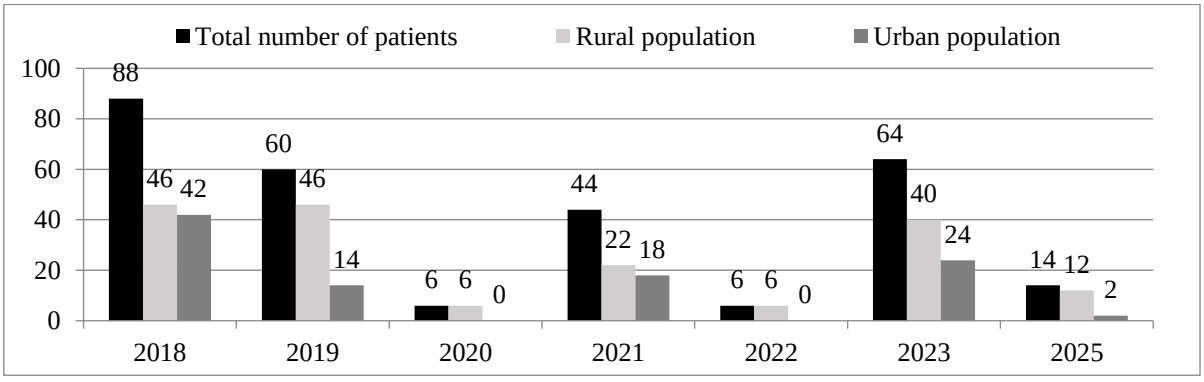

Figure 3. Demographic analysis of patients treated for gastritis.

The subsequent phase of our research involved analyzing the regional distribution of patients who visited the clinic for gastritis treatment (Table 1).

Table 1.

Analysis of patients treated for gastritis by region

№	Administrative regions	Years							Total number
		2018	2019	2020	2021	2022	2023	2025	
1	Tashkent city	34	6	–	14	–	12	–	66
2	Tashkent region	14	10	–	8	2	4	4	42
3	Fergana region	2	4	–	–	–	–	–	6
4	Andijan region	2	2	2	2	–	4	2	14
5	Kashkadarya region	10	6	–	6	2	12	8	44
6	Surkhandarya region	8	6	2	6	–	2	–	24
7	Namangan region	–	–	–	2	–	–	–	2
8	Khorezm region	–	6	–	4	–	6	–	16
9	Jizzakh region	6	8	–	–	–	10	–	24
10	Navoi region	–	–	–	–	–	–	–	–
11	Samarkand region	–	–	2	–	–	–	–	2
12	Sirdaryo region	2	6	–	–	–	2	–	10
13	Bukhara region	4	2	–	–	–	4	–	10
14	Republic of Karakalpakstan	4	4	–	2	2	8	–	20
15	across the Republic of Uzbekistan	88	60	6	44	6	64	14	282

At the Tashkent State Medical University Multidisciplinary Clinic, the majority of patients treated for gastritis were from Tashkent city, Kashkadarya region, and Tashkent region. Over a period of five years, 66 patients from Tashkent city and 216 patients from the regions visited the clinic either by referral or on their own initiative. Additionally, between 2018 and 2025, out of a total of 282 patients, 112 (39.7%) were treated under the state-funded referral system, while 170 (60.3%) received treatment at their own expense. Notably, in 2018, two patients from Kazakhstan were also treated at the clinic.

In the next stage of our study, patient diagnostic indicators were analyzed according to the different forms of the disease (Table 2).

Table 2

Analysis of patients' diagnoses by disease forms in gastritis

№	**Patient diagnosis names**	**Absolute number**	**Relative share, %**
1	Erosive gastritis	4	1,4
2	Subatrophic gastritis	2	0,7
3	Chronic atrophic gastritis	20	7,1
4	Chronic gastritis	36	12,8
5	Chronic gastritis A	6	2,1
6	Chronic gastritis B	208	73,8
7	Chronic superficial gastritis	4	1,4
8	Chronic unspecified gastritis	2	0,7
	Total number and share	**282**	**100**

According to the analysis, between 2018 and 2025, the majority of patients treated at the clinic were diagnosed with chronic gastritis B (73.8%), chronic gastritis (12.8%), and chronic atrophic gastritis (7.1%). The average length of hospital stay for patients with gastritis was 9 days; however, based on the overall condition of the patients, treatment could range from 5 to 7 days.

In the next stage of the study, medical records of 282 hospitalized patients were reviewed to investigate the pharmacoeconomic frequency of drug use in the treatment of the disease. The results of the analysis are presented in the following tables.

Table 3

Pharmacoeconomic frequency analysis of the use of medications applied in the treatment of gastritis disease

№	International nonproprietary name	Dosage Form	Dosage of Medications	Usage Frequency (Relative to the Number of Patients)	Total Sum of Usage	Relative share (relative to the number of patients)	Total quantity of medications used (pieces)
1	Omeprazole	Capsules	20 mg	192	194	68.8%	3004
		Lyophilized powder for injection (vial)	40 mg	2			14
2	Rabeprazole	Capsules	20 mg	34	34	12 %	578
3	Pantoprazole	Tablets	40 mg	34	36	12,7 %	334
		Lyophilized powder for injection (vial))	40 mg	2			10
4	Esomeprazole	Tablets	20 mg	4	6	2,1 %	40
			40 mg	2			20
5	Bismuth tripotassium dicitrate	Tablets	120 mg	16	16	5,6 %	392
6	Metoclopramide	Solution for injection	0,5 %, 2 ml	218	220	78 %	1232
		Tablets	10 mg	2			16
7	Drotaverine	Solution for injection(ampoule)	2 %, 2 ml	168	168	59,5%	961
8	Pancreatin	Enteric-coated tablets	25 DU (100 mg)	118	118	41,8%	2802
9	Activated charcoal	Tablets	250 mg	136	136	48,2 %	3382
10	Aluminum and magnesium compounds Aluminum hydroxide, Magnesium hydroxide, Simethicone	Oral suspension		58	58	20,5%	58
11	Aluminum and magnesium compounds Aluminum hydroxide, Magnesium hydroxide	Oral suspension		12	12	4,2 %	12
12	Aluminum and magnesium compounds Aluminum hydroxide, Magnesium hydroxide, Benzocaine	Oral suspension		4	4	1,4 %	4
13	Lactulose	Syrup in a bottle	667 mg/ml	10	10	3,5%	10
14	Mebeverine hydrochloride	Capsules	200 mg	6	6	2,1 %	80
15	Procaine	Solution for injection	0,5%, 10 ml	184	184	65,2 %	1288
16	Amitriptyline	Tablets	25 mg	60	64	22,7 %	382

		Solution for injection	10 mg/2 ml	4			28
17	Clarithromycin	Tablets	500 mg	2	8	2,8 %	40
			625 mg	2			28
			1000 mg	4			80
18	Sodium chloride + sodium acetate	Solution for infusion	200 ml	96	96	34 %	96
19	Metronidazole	Tablets	200 mg	10	88	31,2 %	210
			250 mg	48			934
		Solution for intravenous infusion, vial	500 mg/100 ml 100 ml (vial)	30			264

According to Table 3, among the main drugs used for the treatment of gastritis, proton pump inhibitors (PPIs) were analyzed for pharmacoeconomic frequency based on their international nonproprietary names (INN). Omeprazole capsules accounted for 75% of the total PPI usage, rabeprazole capsules for 14.45%, and pantoprazole tablets for 8.35%. The relatively high use of omeprazole can be explained by its affordability, popularity, and availability in the clinic's medication supply system. Additionally, activated charcoal 250 mg tablets – 3,382 units, and pancreatin 25 dose units (TBU) tablets – 2,802 units were used. The pharmacoeconomic frequency of recommending these medications to patients was observed to be high. Regarding drug use relative to the number of patients, metoclopramide ranked first, being administered to 220 of 282 patients (78%). Omeprazole was second, used in 194 patients (68.8%), and procaine was third, administered to 184 patients (65.2%). These results reflect the usage of each drug analyzed individually by its INN. As noted above, medications from the PPI pharmacological group are considered the main drugs for gastritis treatment. Analysis of usage frequency relative to the number of patients shows that PPI drugs were used in 270 of 282 patients (95.74%). Furthermore, analysis of the total quantity of drugs used revealed that a total of 4,000 units were administered.

Table 4

Pharmacoeconomic frequency analysis of the recommendation of proton pump inhibitor medications after inpatient treatment

№	**International nonproprietary name**	**Dosage Form**	**Dosage of Medications**	Number of patients prescribed the medication	Relative proportion of patients prescribed the medications, in percentage
1	Omeprazole + domperidone	Capsules	20 mg + 30 mg	18	6,67
2	Rabeprazole	Capsules	20 mg	96	35,55
3	Rabeprazole + domperidone	Capsules	20 mg + 30 mg	2	0,74
4	Pantoprazole	Tablets	20 mg	10	3,7
			40 mg	68	25,18
5	Pantoprazole + domperidone	Capsules	40 mg + 30 mg	24	8,9
6	Esomeprazole	Tablets	20 mg	22	8,15
			40 mg	30	11,12
	Total number			270	100

Analysis of the patient's medical records revealed that proton pump inhibitors medications were recommended to be taken for 20–30 days after inpatient treatment. According to the data presented in Table 4, the highest prescription rates were observed for 'Rabeprazole' 20 mg capsules and 'Pantoprazole' 40 mg tablets

Conclusion

1. The analysis covered the gender, age, demographic characteristics, regional distribution, and pharmacotherapy process of patients treated for gastritis.

2. Based on the medical records of patients treated for gastritis, it was determined that medications with international non-proprietary names–such as omeprazole, activated charcoal, and pancreatin–were used most frequently, indicating higher pharmacoeconomic frequency and associated costs.

3. The various forms of gastritis, their treatment characteristics, the recommended medications, their pharmacoeconomic usage frequency, and the proportion relative to the total number of patients were identified.

4. The retrospective analysis of the medical records of hospitalized patients with gastritis serves as a basis for future pharmacoeconomic evaluations of medication provision, improving treatment effectiveness, and minimizing healthcare expenditures.

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RETROSPECTIVE ANALYSIS OF MEDICAL RECORDS OF PATIENTS WITH UROLITHIASIS

Eshmurodova F.
basic doctoral student of the department Department of pharmaceutical organization of the Tashkent Pharmaceutical Institute
ORCID: 0009-0005-2703-2867
Suyunov N.
Doctor of Sciences in Pharmaceutics, professor, Head of Department of pharmaceutical organization of the Tashkent Pharmaceutical Institute
ORCID: 0000-0002-2712-958X
DOI: 10.5281/zenodo.18081847

Abstract

A retrospective study was conducted on the basis of medical records of 1,839 patients with urolithiasis. The study analyzed the incidence of urolithiasis, risk factors for recurrence, surgical procedures, and medications used to treat the disease. The results showed that urolithiasis occurs mainly in men of working age, and in women, the pharmacoeconomic frequency of drug use in the disease is higher. More than 75% of patients had comorbidities such as dyslipidemia, hypertension, diabetes mellitus, and metabolic syndrome. The most frequently performed surgical methods were percutaneous nephrolithotomy and retrograde intrarenal surgery, and the drugs sodium chloride solution, diclofenac sodium, furosemide, ceftazidime, and extrema were used with the highest pharmacoeconomic frequency in clinical practice, and the costs were higher for these drugs. It was found that their dosage form, dosage, and frequency of use were related to the severity of the disease.

Keywords: urolithiasis, urolithiasis, retrospective analysis, nephrolithotomy, lithotripsy, antibiotic therapy, drugs, patients.

Relevance. In the world, the following studies have been conducted on urolithiasis and its treatment, including retrospective and pharmacoeconomic frequency analyses. In particular, urolithiasis is a metabolic disease that, under the influence of endogenous and exogenous factors, leads to the formation of stones in the urinary tract due to an imbalance in the physicochemical balance of urine. The leading factors of lithogenesis include: lithogenic ion concentration in the urine, lack of crystallization and aggregation inhibitors, the presence of stone-forming factors in the urine, and local changes in the kidneys.

The annual growth trend in the number of patients with urolithiasis from 2016 to 2020 was 23%. A significant factor in this growth is the late diagnosis of the disease, as well as the lack of some early diagnostic methods, in particular, scintigraphy and infrared spectrometry. The lack of an important diagnostic method for analyzing the composition of urinary stones, infrared spectrometry, and first-line non-invasive treatment methods, in particular, extracorporeal shock wave lithotripsy, allows patients with urolithiasis to be referred for examination and treatment or surgical treatment outside the city. The availability of this equipment almost completely eliminates the need for surgical treatment [2].

Urinary tract infection is a common infectious disease, which is mainly treated in hospital. The effectiveness and speed of recovery depend on the correct choice of antibacterial drugs for the treatment of urinary tract infections. The choice of antibacterial therapy for urinary tract infections should be determined by the pathogen. Since treatment should be started before the results of urine culture are known, empirical broad-spectrum antibiotics are used in the treatment of urinary tract infections. However, this leads to a very rapid increase in the resistance of microbes to antibiotic therapy. To reduce this effect and increase the effectiveness of treatment, it is necessary to accurately predict the suspected pathogen and prescribe the most appropriate antibiotic. In the clinical situation of urinary tract infection, it is possible to identify the likely pathogen, which will guide the choice of antibiotic therapy. This review proposes different therapeutic strategies for the treatment of urinary tract infections depending on the suspected pathogen, the clinical situation, and the characteristics of the patient.

Prescribing antibiotics for urinary tract infections is widespread. In fact, in 1997, it was estimated that up to 7 million visits to doctors in the United States were related to urinary tract infections. Information on the epidemiology of urinary tract infections is limited, as such patients often neglect to seek medical help and prefer self-medication. Also, urinary tract infections remain undiagnosed by doctors due to the uncertainty of the clinical presentation and non-specific symptoms of dysuria, which is often present in patients at risk of developing urinary tract infections [7].

Retrospective analysis of outpatient records of patients with urolithiasis who sought examination and specialized medical care at the outpatient department of the N.A. Lopatkin Research Institute of Urology. A retrospective analysis of 1,355 outpatient records of patients with urolithiasis treated for one year was conducted. According to the results, a tendency towards a female predominance was identified among adult patients with urolithiasis. Urolithiasis is more common in patients of working age, both men and women. The highest prevalence of patients of working age compared to patients who are not able to work is observed in male patients, more than three times. The largest number of outpatient visits for urolithiasis occurs in spring and autumn: in April and November. 75.2% of patients with urolithiasis have additional diseases such as dyslipidemia, hypertension, diabetes, and metabolic syndrome. Purine metabolism disorders can be observed not only in patients with uric acid urolithiasis,

but also in patients with calcium urolithiasis and magnesium ammonium phosphate stones.

The overall efficacy of Blemaren in the treatment of patients with hyperuricosuria and uric acid crystalluria, in the prevention of uric acid and calcium oxalate urolithiasis, and in the litholysis of uric acid stones in the absence of infectious or inflammatory processes is 96.9%. The side effect of dyspepsia was noted in less than 3% of patients [4].

Urolithiasis is one of the most common urological diseases. It occurs in all age groups, including children. According to various researchers, urolithiasis occurs in 1-5% of the population in industrialized countries. Bone changes develop only in the most severe, persistent cases of nephrolithiasis. Therefore, the treatment of metabolic bone damage associated with nephrolithiasis is directly related to the metaphylaxis of nephrolithiasis. More precisely, the treatment of skeletal complications is part of metaphylaxis. Drugs used to prevent recurrent stone formation can also be used to treat skeletal complications in some cases. On the contrary, drugs originally developed for the treatment of metabolic osteopathies may reduce the risk of recurrent nephrolithiasis. Theoretical coverage of the treatment of various forms of nephrolithiasis has been provided, but the specifics of drug treatment of patients with recurrent nephrolithiasis and skeletal damage remain relatively scarce.

Drug treatment of patients with renal osteodystrophy associated with nephrolithiasis is still poorly studied. In this clinical situation, it is difficult to even choose a pharmacological group or a specific drug. This is mainly due to the lack of comparative studies [6].

Analysis of the dynamics of changes in the immune status of patients with urinary tract infections is characterized by the transition of acute inflammatory reactions to subacute and chronic reactions, based on the deterioration of phagocytic function and increased indicators of secondary immunodeficiency. This leads to the formation of organ-specific autoallergies, which create a morphological basis for long-term inflammation and damage and should be taken into account in diagnosis and treatment.

Urinary tract infections are the most common type of infection affecting the human body. According to statistics, urinary tract infections are the second most common reason for outpatient treatment after respiratory tract infections. According to the American Urological Association, approximately 7 million patients in the United States visit doctors each year due to urinary tract infections, more than 100,000 patients are hospitalized, and the annual costs associated with this disease exceed $1.6 billion.

The need to distinguish between complicated and uncomplicated urinary tract infections is determined by the differences in their etiology and treatment methods. It should be noted that uncomplicated urinary tract infections can manifest not only with mild and moderate symptoms, but also in severe forms with pronounced signs of intoxication [5].

Urolithiasis, or urinary stone disease, is a widespread condition globally, characterized by a high risk of recurrence and a significant impact on both healthcare systems and the economy. According to research, the lifetime prevalence of this disease among the population of the United States averages 10.1%. In Saudi Arabia, however, the prevalence rate is notably higher, ranging from 13% to 19%. The primary factors influencing the development of the disease include insufficient fluid intake, hereditary predisposition, and dietary habits. Established risk factors consist of low fluid consumption, genetic susceptibility, and nutritional patterns.

A retrospective cohort study was conducted between 2020 and 2025 involving patients aged 18 years and older who had been diagnosed with urolithiasis. After excluding cases with incomplete data, a total of 353 patients were included in the final analysis. Factors such as age, sex, body mass index, and glomerular filtration rate were taken into account. According to the study results, patients who received vitamin D supplementation—particularly at higher doses—showed an increased likelihood of urolithiasis recurrence. This finding indicates the need to determine vitamin D dosage based on individual patient characteristics. Furthermore, the data emphasize the importance of conducting additional prospective studies to identify safe dosage thresholds for patients predisposed to stone formation.[1]

According to the World Health Organization, the prevalence of kidney stones in men and women in 2017–2018 was 11.9% and 9.4%, respectively. Over the past decade, the gender gap in the prevalence of kidney stones has been decreasing, and this trend is especially noticeable among women under 60 years of age. Retrospective studies aimed to study gender differences and the risk of developing chronic kidney disease among patients with kidney stones. According to the results of the study, the probability of developing chronic kidney disease is different between male and female patients, and the gender factor plays an important role in assessing the individual risk of patients. Data on patients diagnosed with kidney stones between 2013 and 2018 were retrospectively analyzed and divided into two groups according to gender. The study examined the clinical and demographic characteristics of the patients, the location and composition of the stones, the chemical parameters of urine and renal function. The study included 1,802 patients, with a higher proportion of male patients (1,312 men and 490 women). Hypertension, diabetes mellitus and dyslipidemia were more common in women, while calcium-containing stones, in particular calcium oxalate, uric acid and struvite stones, were dominant in men. Carbonate apatite stones were more common in women. Advanced surgical techniques and percutaneous nephrolithotomy and ureterorenoscopic lithotripsy were used more often in women than in men. The results of multivariate analysis showed that patients older than 60 years, female gender, uric acid stones, hypertension and diabetes were significant independent risk factors for the development of chronic kidney disease [3].

Study Objective. The objective of the study was to conduct a retrospective analysis of the medical records of hospitalized patients with urolithiasis and to

perform a pharmacoeconomic frequency analysis of the medications used in their treatment.

Research Methods. The study utilized the medical charts of hospitalized patients diagnosed with urolithiasis at the Polyclinic of the Republican Specialized Scientific-Practical Medical Center of Urology. A total of 1,802 surgical procedures were included in the retrospective analysis, of which 702 were performed on female patients and 1,100 on male patients. The research applied methods such as retrospective analysis, comparison, grouping, statistical evaluation, and pharmacoeconomic frequency analysis. Among pharmacoeconomic assessment techniques, quantitative frequency analysis was used to determine, based on evidence, whether specific medications were prescribed or not.

Results and Discussion. A total of 1,802 percutaneous surgical procedures were performed, including 702 procedures in female patients and 1,100 in male patients. Among these, surgeries conducted for the diagnoses "nephrolithotripsy for staghorn and multiple stones," "nephrolithotripsy for a single stone," and "nephrolithoextraction" accounted for 70.7% of all operations. Specifically, these procedures were performed in 516 women (representing 73.5% of all surgeries conducted in women) and in 758 men (representing 64.9% of all surgeries conducted in men). Furthermore, nephrolithotripsy for a single stone was performed in 485 patients, including 215 women and 270 men. Nephrolithotripsy for wheat-horn–type and multiple stones was performed in 457 patients, including 160 women and 297 men. Nephrolithoextraction was carried out in 332 patients, including 141 women and 191 men.

$$\textbf{\textit{Percentage of male patients}} = \left(\frac{\text{Number of male patients}}{\text{Total number of patients}}\right) \times 100 = \frac{1117}{1838} \times 100 = 60{,}8$$

$$\textbf{\textit{Percentage of male patients}} = \left(\frac{\text{Number of female patients}}{\text{Total number of patients}}\right) \times 100 = \frac{721}{1838} \times 100 = 39{,}2$$

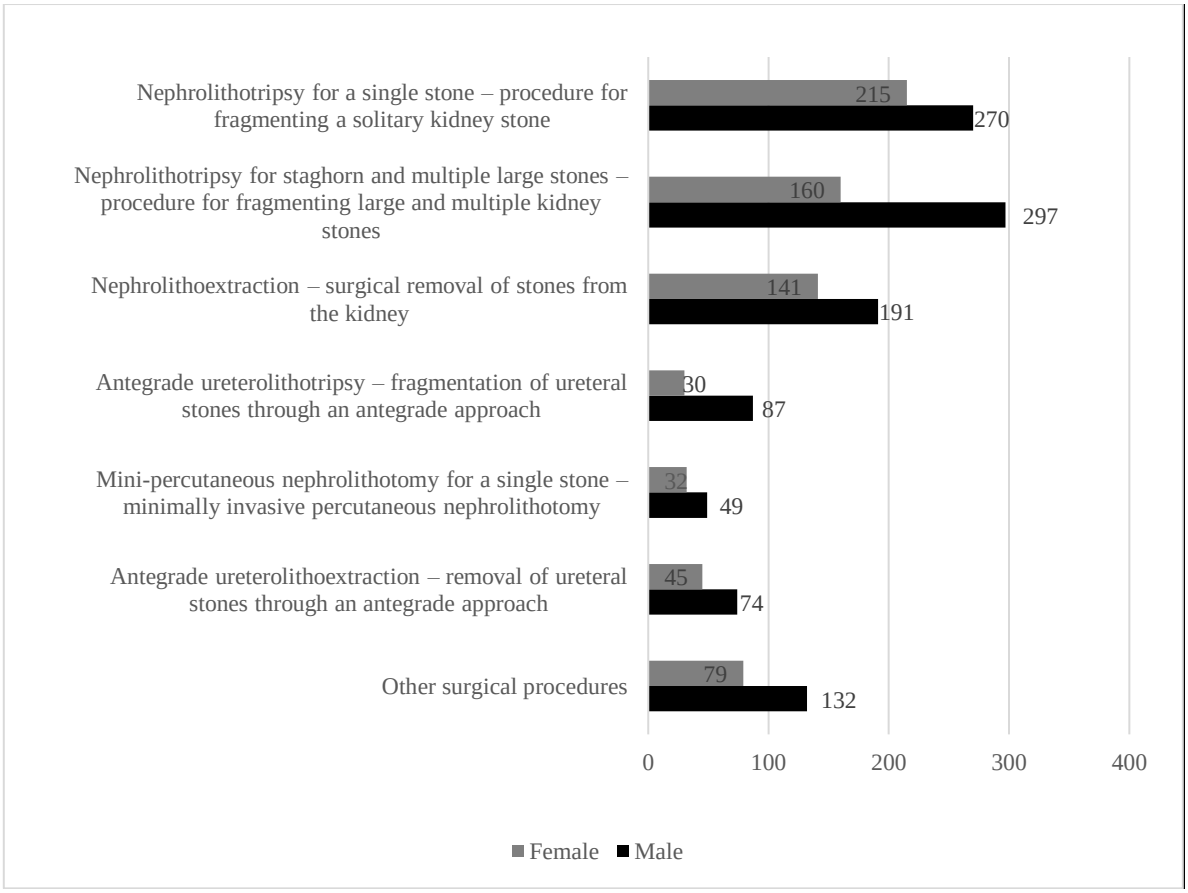

Figure 1. Grouping of patients by age

In this type of surgery, the number of patients under the age of 20 is 40, 2.2% of the total number of patients, 595 from 21 to 40 - 33.0%, 775 from 41 to 60 - 43.0%, 392 from 61 to 80 - made up 21.8%.

$$\text{Age group percentage} = \left(\frac{\text{Number of patients in the age group}}{\text{Total number of patients}}\right) \times 100$$

Percentage of the 0–20 age group = (76 / 1838) × 100 = 4.1%
Percentage of the 21–40 age group = (595 / 1838) × 100 = 32.4%
Percentage of the 41–60 age group = (775 / 1838) × 100 = 42.2%
Percentage of the 61–80 age group = (385 / 1838) × 100 = 20.9%
Percentage of the 81–100 age group = (7 / 1838) × 100 = 0.4%

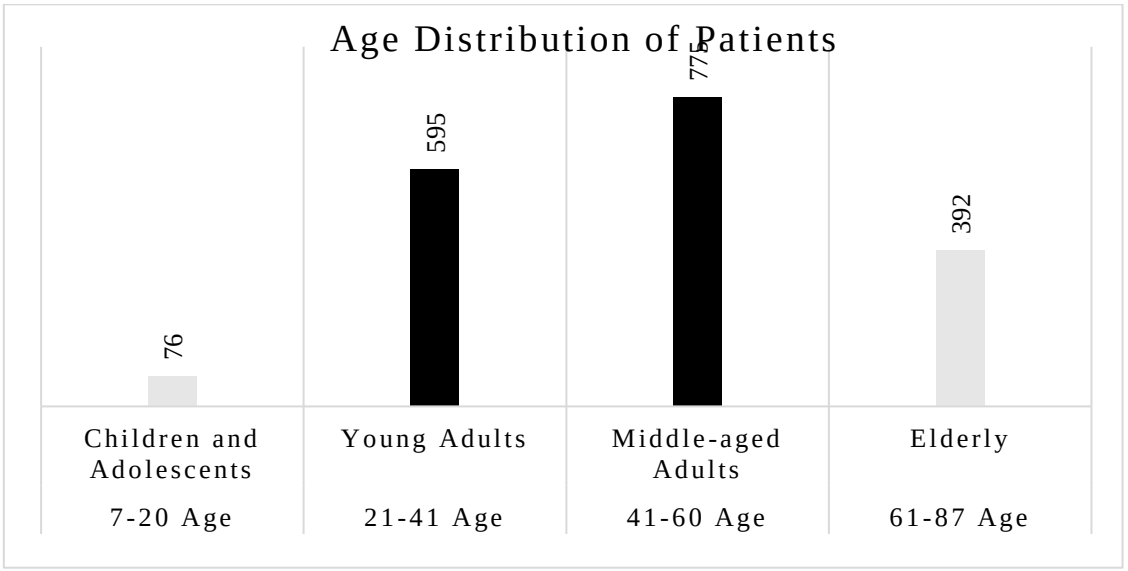

Figure 2. Age group indicators of patients

In the distribution of treated patients by region, those from Tashkent region and Tashkent city made up the main part. Of these, 518 people came from Tashkent city and 558 from Tashkent region.

Within the framework of the study, based on the diagnoses of a total of 1,838 patients, a total of 45,627 times of drug use were recorded according to pharmacoeconomic frequency. Among the most commonly used drug dosage forms, the drug "Sodium chloride solution – 0.9%, 500.0 (M)" occupied a special place, which was used 2,478 times. It was also observed that "Sodium chloride solution – 0.9%, 5 ml, No. 10 (M)" was used – 2,007 times, "Diclofenac sodium 2.5%, 3 X 10" – 1,443 times, "Extref vial, 2 g (M)" – 1,292 times.

In addition, according to the research results, "Furasemide 1%, 2 X 10 (M)" - 1,170 times, "Ceftazidime 1 g (M)" - 786 times, "Dimedrol 1%, 1 X 10 (M)" - 678 times, "Analgin solution 50%, 2 ml, No. 5 (M)" - 655 times, "Diclofenac suppository" 100 mg, No. 10 (M)" - 486 times, and "Novocaine solution 0.5%, 5 X 10 (M)" - 470 times. The data, studied within the disease treatment protocols, show a high demand for certain drugs, confirming their importance in practice and priority in clinical processes.

Table 1

Pharmacoeconomic Frequency Analysis of Medications Used in the Treatment of Urolithiasis

No.	International Nonproprietary Name (INN)	Dosage Form	Drug Dosage	Frequency of Use	Total Usage Count
1	Sodium chloride solution	Solution for infusion	0.9% / 500 ml	2478	2 478
2	Sodium chloride solution	Solution for infusion	0.9% / 5 ml	2007	2 007
3	Diclofenac sodium	Solution for injection	2.5% / 3 ml	1 443	1 929
4		Rectal suppositories	10 mg / 10	486	
5	Extref	Powder for preparation of injection solution	2 mg per vial	1 292	1 292
6	Furosemide	Concentrate for preparation of infusion	1% / 2 ml	1 170	1 170
7	Ceftazidime	Powder for preparation of injection;	1 mg per vial	786	786
8	Diphenhydramine	Solution for infusion	1% / 1 ml	678	678
9	Analgin (Metamizole sodium)	Solution for injection	1% / 1 ml	655	655
10	Novocaine	Solution for injection	50% / 2 ml	470	470

Diclofenac sodium 2.5%, 3 X 10 was found to be used in approximately 70% of the patients studied in the study. The analysis shows that the number of use of this medicinal product mostly did not exceed 4 times.

In particular, this drug was used up to 4 times in patients treated with the diagnoses “C 67 right kidney formation, cT1bN0M0, RENAL 11H/ SPO - organ with pathology; percutaneous nephrolithotomy; left and “N 20.0 ICD (C67 - Malignant tumor of the urinary bladder according to the International Classification of Diseases (ICD-10); Stones in the right kidney; Hydronephrosis on the right side; Body mass index; ASA III; Anesthesiological risk level III; At the same time, “N 20.0 ICD; Stones in the renal pelvis of the right kidney; Hydronephrosis on the right side; Body mass index” ASA III” and “N 20.1 STK; Stones in the right back; Hydronephrosis on the right side; Body mass index” ASA III” In patients treated with diagnoses such as nephrostomy; Urinary tract infection; Anesthesia risk level II (ASA II), this drug was usually used up to 3 times. 23% of patients who used this drug used up to 2 times, and the remaining 87% used it once. This distribution indicates that “Diclofenac sodium” is actively used mainly as an adjuvant therapy to reduce pain and control inflammation. It also means that the frequency and dosage of the drug are determined depending on the clinical condition of the patient, the severity of the disease and individual characteristics.

The use of the drug "Extref vial, 2 g (M)" was relatively limited, and it was found that it was used mainly in patients with severe clinical conditions. The analysis shows that this drug was used up to 4 times during the treatment of only three patients with the following diagnoses.

N20.1 N2 (ICD code). Fragmented stones located in the upper and lower one-third of the left ureter; left-sided ureteral hydronephrosis; urinary tract infection; acute complicated pyelonephritis on the left side. N20.1 (ICD code) – Stone in the upper one-third of the right ureter; right ureteral hypertrophy; urinary tract infection; acute complicated pyelonephritis on the right side; newly diagnosed type 2 diabetes mellitus; stone in the lower one-third of the left ureter; left ureteral hypertrophy; body mass index; acute complicated pyelonephritis on the left side; stone at the lower end of the left ureter; left-sided hydronephrosis; body mass index; repeated episodes of acute complicated pyelonephritis on the left side.

In the remaining cases, the frequency of use of the drug was relatively low, with only 3% of the total number of patients taking it up to 3 times. At the same time, 44% of patients used the drug 2 times, and the remaining 52% used it only 1 time. Statistical data indicate that the drug "Extref Flakon" is used mainly as an adjuvant therapy in cases of severe complicated pyelonephritis, ureterohydronephrosis, accompanied by a high degree of inflammation during the diagnosis process. It is noted that the differences in the frequency of dosing are associated with the clinical condition of the patient, the severity of the disease, and individual reactions.

Table 2

Number of users	**Diclofenac sodium 2,5 %, 3 X 10**		**Extref vial 2 g 2 г (M)**		**Furo-semide 1 %, 2 x 10 (M)**		**Ceftazidime 1 g vial**		**Diphenhydramine injection 1 %, 1 X 10 (M)**	
	Number of patients	Proportion of patients who used (%)	Number of patients	Proportion of patients who used	Number of patients	Proportion of patients who used (%)	Number of patients	Proportion of patients who used (%)	Number of patients	Proportion of patients who used (%)
Once/QD	1106	87	446	52	886	86	245	49	641	97
Twice daily/BID	148	12	381	45	136	13	232	46	17	3
Three times daily/ TID	11	1	24	3	4	0,4	21	4	1	0,2
Four times daily/ QID	2	0,2	3	0,4	–	XXX	2	0,4	XXX	XXX
Five times daily	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX	XXX
Six times daily	XXX	XXX	XXX	XXX	XXX	XXX	1	0,2	XXX	XXX
Total	1267	69	854	47	1026	56	501	27	659	36

The drug “Furasemide 1%, 2x10 (M)” was found to be used in the treatment of approximately 56% of the patients studied in the study. In particular, this drug was used in the treatment of “N20.0 ICD – Right kidney stones; Right kidney hydronephrosis; Body mass index; ASA III”; N20.0 ICD; Left kidney stones; Left hydronephrosis; Left renal colic; Hypoplastic right kidney CRF; “N20.0 ICD; Right renal calculus; Right-sided hydronephrosis” and “N20.2 ICD – Stones in the right renal pelvis and ureter; Right-sided hydronephrosis; Acute complicated pyelonephritis on the right side were observed. It was most often used in patients undergoing treatment with a diagnosis of severe inflammatory process in the body, and the drug was used up to 3 times in total. Also, the analysis shows that 272 of the patients participating in the study used the drug up to 2 times, and the remaining 886 patients used it only once.

The drug “Ceftazidime 1 g (M)” was used in the treatment of approximately 27% of the patients studied in the study. The drug was used more often in particularly severe clinical cases, and in one patient with the diagnosis “N 20.0 ICD. Right kidney stones; Right kidney hydronephrosis; Body mass index; ASA III” it was used up to 6 times.

Similarly, in patients treated with the diagnoses ‘N20.0 ICD — stones in the right kidney; right-sided hydronephrosis; body mass index; ASA III’ and ‘N20.2 ICD — a stone in the upper one-third of the right ureter and multiple stones in the left renal pelvis; right-sided ureteral hydronephrosis; left-sided hydronephrosis,’ the frequency of drug administration reached up to four times. In the remaining cases, the medication was administered up to three times in 21 patients, twice in 232 patients, and only once in 245 patients.

Such a distribution indicates that ceftazidime is primarily used as an active therapeutic agent in cases accompanied by severe infectious complications, with the aim of eliminating inflammation and controlling the infection.

Diphenhydramine 1%, 1 × 10 (M) was used in a total of 659 patients within the study cohort, accounting for approximately 36% of all patients. Although the medication was administered once in most cases, some patients received it more frequently.

In particular, in the patient diagnosed with ‘N20.0 ICD — blood clots in the urinary bladder; non-functioning nephrostomy on the left side; missing stent on the left side; post-percutaneous nephrolithotomy condition on the left side,’ the medication was administered up to three times. Additionally, it was administered up to two times in 17 patients, while in the remaining 641 patients it was administered only once.

These data indicate that diphenhydramine is primarily used as an adjunctive therapeutic agent to prevent allergic reactions and provide anti-inflammatory effects, while its dosing frequency is determined according to the patient’s clinical condition.

Conclusion.

1. It has been established that the correct timing of surgical intervention to optimize drug therapy in the treatment of patients with urolithiasis plays an important role in reducing the risk of disease recurrence.

2. In terms of pharmacoeconomic frequency in urolithiasis, the frequency of drug use in patients treated with a diagnosis of left-sided hydronephrosis reached 4 times. In the remaining cases, the drug was used up to 3 times in 21 patients, up to 2 times in 232 patients, and only 1 time in 245 patients. It was found that Ceftazidime was used mainly as an active therapeutic agent in cases with severe infectious complications, to eliminate inflammation and control infection.

3. According to the pharmacoeconomic frequency analysis of drugs used in the treatment of urolithiasis, it was proven that "Extref" vial, 2 g, "Furasemide" 1%, 2 x 10, "Ceftazidime" 1 g - according to medical evidence, are widely used in the treatment process and constitute the largest part of the costs.

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PHILOLOGICAL SCIENCES

СУБСТАНТИВАЦИЯ И СОБИРАТЕЛЬНОСТЬ: ТЕОРЕТИЧЕСКИЕ ОСНОВАНИЯ И ФУНКЦИОНАЛЬНО-СЕМАНТИЧЕСКИЕ ПАРАМЕТРЫ (НА МАТЕРИАЛЕ РУССКОГО И БОЛГАРСКОГО ЯЗЫКОВ)

Лазарова Е.Г.
Шуменский университет им. Константина Преславского, аспирант

SUBSTANTIATION AND COLLECTIVITY: THEORETICAL FOUNDATIONS AND FUNCTIONAL-SEMANTIC PARAMETERS (BASED ON MATERIAL FROM THE RUSSIAN AND BULGARIAN LANGUAGES)

Lazarova E.
Konstantin Preslavsky University of Shumen, doctoral student
DOI: 10.5281/zenodo.18081861

Аннотация

Предлагается попытка осмысления субстантивной собирательности с когнитивной точки зрения. Целью при этом является определение роли, которую играет собирательность в системе знаний человека о мире, и, исходя из этого, – места в системе языка существительных, обладающих значением собирательности. В результате признается, что собирательность тесно связана с понятийной и семантической категорией количественности (квантитативности), являясь одной из разновидностей несчетного количества, а субстантивация формирует особый пласт лексики, расположенный в ядре категории собирательности. Такое решение вопроса является новым и представляет перспективу для развития идей семантического подхода к явлению субстантивной собирательности.

Abstract

An attempt to interpret the substantive collectivity from a cognitive point of view is offered. The purpose of this is to determine the role that collectivity plays in the system of human knowledge about the world, and, based on this, places in the language system of essentials that possess the meaning of collectivity. As a result, it is recognized that collectivity is closely related to the conceptual and semantic category of quantity (quantity), being one of the varieties of uncountable quantity, and substantivation forms a special layer of vocabulary located in the core category of collectivity. Such a solution to the question is new and presents a perspective for the development of the idea of the semantic approach to the expression of substantive collectivity.

Ключевые слова: категория собирательности; несчетное количество; собирательное существительное, субтантивация.

Keywords: collectability category; uncountable amount; collective noun, subtantivation.

Субстантивация как переход слов из одной части речи в другую является одним из наиболее продуктивных механизмов развитых языковых систем. Она представляет собой особый тип морфолого-синтаксического словообразования, в котором изменение синтаксической функции сочетается с категоризующим преобразованием лексико-грамматической природы слова. В русской и болгарской лингвистических традициях субстантивация прилагательных последовательно описывалась как переход признакового слова в сферу предметной номинации. Еще в болгарских грамматиках XIX века Й. Груев обращал внимание на случаи, когда прилагательное «становится именем существительным», т.е. приобретает значения носителя признака, а не самого признака [2]. Подобные наблюдения развил Ал. Теодоров-Балан, определивший сущность субстантивации как «переход прилагательного в существительное» вследствие полного ослабления связи между определяемым и определением [9]. В русской лингвистике аналогичную позицию занимал А. М. Пешковский, который рассматривал субстантивацию как типичную форму перехода, при котором «прилагательное перестает обозначать признак и начинает обозначать носителя признака» [7]. Таким образом, функциональный переход сопровождается глубокими семантическими и грамматическими изменениями.

Проблематика субстантивации тесно связана с общими теориями переходных явлений. В работах А. А. Шахматова субстантивация понимается как преобразование, при котором «наименования признаков переходят в разряд существительных» [11]. Шахматов отмечает, что явление нельзя сводить лишь к синтаксическому переключению, поскольку оно затрагивает категориальное значение единицы. В дальнейшем понятие перехода рассматривается через концепцию транспозиции, предложенную Ш. Балли, который определяет её как изменение функционально-категориального значения языковой единицы при сохранении внешней формы [13]. Е. С. Кубрякова развила эту идею, трактуя субстантивацию как морфологическую транспозицию, связанную с изменением парадигмы и категоризую-

щей принадлежности слова, что позволяет рассматривать её как подлинный способ словообразования [4]. Эта трактовка коррелирует с современными подходами, рассматривающими субстантивацию как разновидность конверсии, при которой слово получает статус новой лексемы в системе языка.

В болгарской грамматической традиции существенное значение имеет разграничение степеней субстантивации. Ст. Стоянов выделил три типа самостоятельного употребления прилагательных: эллипсис определения, употребление, склоняющееся к субстантивации, и собственно полная субстантивация, при которой прилагательное «означает предмет» и входит в парадигму существительного [8]. Ив. Недев уточнил критерии елиминирования определяемого, различая случаи, когда эллипсис обусловлен контекстом, и случаи, когда прилагательное употребляется в чисто номинативной функции [6]. Наиболее системное описание представила Л. Крумова, подчёркивающая, что лишь полная субстантивация должна считаться истинным словообразовательным процессом, так как она сопровождается изменением лексического значения и морфологической парадигмы [3]. Болгарская традиция, таким образом, выработала точные критерии для определения момента перехода прилагательного в разряд существительных.

Субстантивация нередко сопровождается формированием собирательной семантики. В русском языке многочисленные субстантивированные прилагательные обозначают группы лиц: *бедные, молодые, учёные, русские, больные, старшие* и др. Эти формы представляют собой обобщённые номинации, в которых исходное качественное значение переосмысляется в категориально-предметное. Как отмечает В. В. Виноградов, подобные образования «обозначают социальные или возрастные слои» и выступают как собирательные именования [1]. Подобная функция ярко проявляется в конструкциях типа *Бедные не понимают богатых*, где субстантивированные прилагательные функционируют как имена классов людей. В болгарском языке аналогичные образования (*добрите, младите, болните*) благодаря системе определённого члена обладают еще более высокой степенью грамматикализации, что способствует устойчивости собирательного значения.

Современные исследования показывают, что субстантивация прилагательных является одним из важнейших механизмов формирования функционально-семантического поля категории собирательности. Данное поле включает разнообразные средства выражения собирательных значений: собственно собирательные существительные (*молодёжь, детвора, листва*), собирательные числительные (*двое, трое, семеро*), словообразовательные форманты (*-ьё, -ота, -ня*), а также субстантивированные формы прилагательных. По мнению Е. В. Кустовой, собирательность представляет собой интегративную категорию, объединяющую явления количественной множественности и концептуальной целостности, благодаря чему в её ядро входят единицы, обозначающие группы как неделимые множества [5]. Субстантивированные прилагательные органично вписываются в эту систему, поскольку они обозначают классы объектов, объединённых общим признаком, и тем самым склоняются к представлению группы как целого, а не как суммы индивидов.

Механизм возникновения собирательного значения в процессе субстантивации может быть описан следующим образом. Во-первых, происходит семантическое преобразование: признак, подразумеваемый в прилагательном, интерпретируется как характеристика группы людей, а не отдельных индивидов. Во-вторых, прилагательное приобретает предметную референцию, заменяя номинацию типа *бедные люди*. В-третьих, закрепляется грамматическое оформление: субстантивированная форма начинает употребляться с определителем, согласуется как существительное и может образовывать формы падежа. В результате возникает новое лексическое значение, в котором собирательность становится ядром семантики. Этот процесс подробно описан в работах Н. Д. Арутюновой и В. Н. Ярцевой, связывавших субстантивацию с механизмами абстрагирования и обобщения [12].

Сопоставление русского и болгарского материала позволяет выявить ряд типологических особенностей. В русском языке собирательность чаще формируется на базе абстрагированных семантических сдвигов и закрепляется через исторически сформированные модели (*молодёжь, детвора, ребятня*). В болгарском языке благодаря членным формам переход прилагательного в существительное является более частым и регулярным, что делает субстантивированные формы центральным средством оформления собирательности (*добрите, старите, младите*). Таким образом, в болгарском языке субстантивация чаще выступает как продуктивный синхронный процесс, тогда как в русском – как исторически закреплённое словообразование, хотя оба языка демонстрируют схожие закономерности в формировании собирательных значений.

Важно отметить, что субстантивация прилагательных тесно связана с концепцией переходных явлений в языке. Как отмечает Т. С. Тихомирова, переход не всегда сопровождается изменением формы, но всегда предполагает изменение синтаксической функции и категоризационного значения [10]. Субстантивация в этом контексте выступает как предельная форма перехода, при которой прилагательное полностью утрачивает свои исходные признаки и включается в систему существительных. Такое включение отражается и в парадигматике: субстантивированные формы начинают участвовать в словообразовательных процессах, свойственных существительным, напр. *богатый → богатеи*, *бедный → беднота*, *молодой → молодёжь*. Подобные трансформации подтверждают, что субстантивация не только меняет синтаксическую роль слова, но и создаёт предпосылки для возникновения новых словообразовательных гнезд и лексико-семантических групп.

Особенно показательны случаи, когда субстантивация приводит к образованию прототипических собирательных существительных. Суффиксальные

модели *-ств-, -от-, -нь-, -ё* часто развиваются на базе субстантивированных прилагательных или форм признаком означающих слов. Например, *молодёжь* исторически восходит к прилагательному *молодой*, *беднота* – к *бедный*, *ребятня* – к *ребята*. Подобные примеры демонстрируют, что субстантивация формирует семантическую базу для дальнейшего словообразования, укрепляя тенденцию к представлению группы как единого целого. Соответственно, субстантивированные прилагательные располагаются в переходной зоне функционально-семантического поля собирательности, связывая индивидуальные и групповые номинации.

С точки зрения общей теории категорий, субстантивация представляет собой механизм категоризации, при котором признак превращается в сущность, а признаковая характеристика – в носителя признака. В рамках когнитивного подхода это может быть интерпретировано как переход от качественного признака к понятию класса или группы, что совпадает с базовыми механизмами концептуализации собирательности. Следовательно, субстантивация играет ключевую роль в структурировании семантического пространства собирательности и формирует важную зону внутри его функционально-семантического поля.

Таким образом, анализ материала русского и болгарского языков позволяет утверждать, что субстантивация является одним из важнейших источников собирательных значений. Она участвует в формировании собирательной семантики как непосредственно – через субстантивированные формы (*бедные, младите*), так и косвенно – как база для дальнейшего словообразования (*молодёжь, крестьянство, ученичество*). Субстантивация обеспечивает переход признаковых характеристик в собирательную предметность и способствует концептуализации групп как единого целого. Русский и болгарский языки демонстрируют в этом отношении как типологическое сходство, так и структурные различия, обусловленные их грамматическими системами. Однако общим остаётся фундаментальное свойство: субстантивация формирует особый пласт лексики, расположенный в ядре категории собирательности.

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SPEECH ETIQUETTE AND COMMUNICATION CULTURE OF MODERN STUDENTS

Zeynalova T.
Senior Teacher
Azerbaijan University of Languages,
Department of Lexicology of the English Language
Azerbaijan, Baku
DOI: 10.5281/zenodo.18081868

Abstract

The rapid progress of information technologies and the increasingly dominant role of digital communication platforms have significantly reconfigured how today's students engage in communicative practices. As active members of digital interaction spaces, students must operate across a variety of communication formats, which elevates the importance of speech etiquette and communication culture as essential dimensions of academic, social, and professional competence. This article explores how these competencies support effective communication, facilitate mutual understanding, and contribute to students' professional socialization within higher education. Special emphasis is placed on the need for intentional selection of speech strategies, adherence to communication norms, and awareness of sociocultural factors in complex contemporary communication environments. The article contends that the ability to convey ideas clearly, ethically, and contextually appropriately is becoming a universal requirement for professionals in the digital era. Strengthening students' communication culture and speech etiquette is therefore identified as a crucial responsibility of modern higher education institutions, promoting both personal development and successful integration into academic and professional communities.

Keywords: speech etiquette; communication culture; digital communication; professional socialization; higher education; communicative competence; interaction strategies; sociocultural context; digital environment; interpersonal communication.

Introduction

In the contemporary landscape shaped by rapid developments in information technologies, digital platforms, and social media, communication practices are undergoing significant and continuous change. These transformations are particularly noticeable among students, who are among the most active and adaptable users of digital environments. Consequently, speech etiquette and communication culture are increasingly recognized as crucial elements of academic achievement and social interaction. They involve not only knowledge of language norms but also the ability to communicate with respect, empathy, tolerance, and responsibility toward others.

As communication spheres broaden, students must adapt to multiple modes of interaction—from official correspondence and academic discourse to online exchanges on social networks, messaging applications, and digital learning systems. Choosing appropriate communication strategies, following established behavioral norms, and demonstrating sensitivity to sociocultural contexts become essential for developing professional competency, building strong interpersonal relationships, and encouraging constructive dialogue in educational settings.

Furthermore, verbal communication culture is a key factor in students' professional socialization. In an era where digitalization influences nearly every social domain, the capacity to articulate ideas clearly, accurately, and ethically has emerged as a fundamental professional skill. Honoring speech etiquette strengthens one's communicative reputation, improves interaction effectiveness within academic and professional communities, and supports the formation of lasting, trust-based social relationships. For these reasons, fostering communication culture is both a personal priority and a socially important mission for modern higher education.

The Importance of Speech Etiquette in Everyday Communication Practices

Speech etiquette encompasses one's ability to communicate in accordance with ethical, cultural, and social expectations; to structure exchanges according to context and purpose; and to demonstrate respect and courtesy toward others. Linguists view speech etiquette not only as a collection of linguistic rules but also as a behavioral norm, an interactive strategy, and a mechanism for maintaining social order. Scholars widely acknowledge it as a key tool for regulating relationships, promoting efficient communication, and ensuring harmonious interpersonal interaction.

Geoffrey Leech argues that politeness forms the foundation of speech etiquette, emphasizing behavioral qualities such as respect, modesty, and warmth. In a similar manner, Brown and Levinson's (1987) influential politeness theory proposes that individuals aim to protect their own and others' "face," which represents personal dignity and social identity. From this perspective, speech etiquette minimizes conflict, maintains interpersonal harmony, and fosters mutual respect.

Speech etiquette is also closely linked with H. P. Grice's cooperative principles. Grice (1975, pp. 41–58) asserts that communication is guided by the maxims of quantity, quality, relation, and manner, all of which support clarity and mutual understanding. Observing these maxims reflects the pragmatic aspect of speech etiquette and enhances communicative effectiveness.

Sociologist Erving Goffman (1967) adds another dimension by emphasizing that individuals actively manage their public image or "face" to preserve trust, credibility, and social stability. Thus, culturally appro-

priate communication fulfills both social and psychological roles, reinforcing one's position within a group and supporting positive interpersonal connections.

Everyday Examples of Speech Etiquette

In daily interactions, speech etiquette is expressed through both verbal and nonverbal behaviors—greetings, expressions of gratitude, apologies, polite requests, proper forms of address, and careful use of tone, gesture, and facial expression. These behaviors perform cultural, psychological, and social functions in communication.

Example:

A student who arrives late to class gently opens the door and says:

"I'm sorry for being late. I hope I didn't disturb the class."

This aligns with Lakoff's (1973, pp. 292–305.) principles of politeness and reflects Brown and Levinson's face-protection strategies.

Counterexample:

A student who enters late without greeting or apologizing violates Grice's cooperative maxims—especially relevance and manner—and disregards basic politeness norms. Such behavior may signal indifference or lack of communicative awareness.

The Significance of Communicative Culture and Its Role in Human Interaction

Communication culture refers to the ability to build honest, clear, and ethical relationships with others. It is demonstrated not only through spoken language but also through nonverbal cues such as tone, gestures, facial expressions, and attentive listening. As Goffman (1967) notes, maintaining one's social "face" is central to successful interaction, while Leech (1983) highlights that ethical and polite communication reduces conflict and strengthens mutual trust.

This concept also relates closely to speech act theory (Austin, 1962; Searle, 1969), which posits that every utterance performs a social action. For instance, politely expressing disagreement or making a respectful request conveys information while preserving the interlocutor's dignity. Such communication demonstrates pragmatic competence and adherence to ethical standards.

Brown and Levinson's (1987) concept of politeness strategies further emphasizes the importance of protecting both one's own "face" and that of others. Deborah Tannen (1990) similarly notes that cultural norms and conversational styles shape how messages are interpreted, especially in hierarchical communication settings such as classrooms.

Example:

A student who politely disagrees, saying:

"With your permission, I would like to offer a different perspective," shows respect, follows communicative norms, and promotes constructive dialogue.

Counterexample:

A confrontational or dismissive expression of disagreement violates basic principles of

communicative culture, increases the likelihood of conflict, and damages the speaker's social image.

Effective communication culture, therefore, is essential for personal growth, academic engagement, and professional development. It enhances interpersonal effectiveness, encourages positive relationships, and supports ethical and culturally sensitive interaction in educational environments.

The Impact of Technology on Contemporary Students

Technology—especially social media—has dramatically altered how students communicate. Shortened messages, slang, and informal vocabulary increasingly appear in everyday interactions.

Example of poor email etiquette:

"Hello. I will not be attending class. Thank you."

This format is inappropriate in formal academic communication.

Improved version:

"Dear [Teacher's Name], due to personal reasons, I am unable to attend class today. Thank you for your understanding."

Additional contrasts:

Informal: *"Hi, I'm not coming to class."*

Formal: *"Dear [Teacher's Name], I will be unable to attend today's class due to a valid reason. Thank you for your understanding."*

Informal: *"I didn't do my homework, sorry."*

Formal: *"Dear [Instructor], I was unable to complete my homework for today. May I request an extension? Thank you."*

Informal: *"What do I do for the lab?"*

Formal: *"Hello [Instructor], I have a few questions regarding the lab assignment. Could you clarify certain points?"*

These examples highlight that formal communication requires polite address, clear purpose, and expressions of gratitude—elements not typically expected in informal student communication but essential in academic and professional contexts.

The Impact of Aggressive and Passive Communication Behaviors

Students who lack well-developed communication abilities may sometimes express themselves in ways that are either overly aggressive or excessively passive.

For instance, a student might address a peer by saying:

"You don't know anything. Why are you even sharing your opinion?"

Such remarks are disrespectful and undermine productive dialogue. A student with stronger communication competence would instead respond more constructively, for example:

"I'm interested in hearing your perspective, but my viewpoint differs slightly. If you don't mind, I would like to explain it."

Scholars emphasize that aggressive communication typically triggers defensiveness and negatively affects group interaction and cohesion (Deutsch, 1973). Conversely, passive behavior may result in confusion and escalating tension because individuals fail to articulate their true thoughts and emotions (Thomas, 1992). According to Alberti and Emmons (2017), developing assertive communication skills enables students to express themselves clearly while maintaining respect for others, thereby fostering constructive exchanges and minimizing conflict.

Bandura's (1977) social learning theory further highlights that young people often imitate the behavioral patterns they observe, which means that positive communication habits cultivated early on support healthy long-term development. Rogers (1961) also argued that empathic communication helps establish trust and reduces aggressive reactions. In addition, research by Collins and Miller (1994) shows that openly expressing one's thoughts, emotions, and intentions strengthens interpersonal bonds and enhances understanding within a group.

Therefore, promoting assertive, respectful, and balanced communication skills among students contributes to healthier interaction, reduces tension and misunderstandings, and creates a supportive environment for discussion and collaborative learning.

Enhancing Communication Abilities Through Problem-Solving Strategies

Cultivating strong communication and problem-solving abilities is a fundamental goal of education. Various instructional strategies are used to develop speech culture, enhance critical and analytical thinking, and strengthen students' argumentative and collaborative skills. The table below (completed with relevant content) presents the main problem-solving approaches, offering explanations for each method along with practical examples that show how students utilize them both in their academic work and in everyday communication situations.

Method	Revised Description (Paraphrased	Paraphrased Examples
Training and Preparation	Organizing instructional sessions, such as workshops or masterclasses, designed to strengthen students' verbal communication and presentation abilities.	– The training session titled *"Leadership Through Speech"* enabled participants to enhance their verbal culture and expressiveness. – A masterclass on public speaking assisted students in reducing performance anxiety and presenting their ideas more confidently.
Debates and Public Speaking Clubs	Participation in debate formats and speaking clubs develops students' analytical reasoning, persuasive communication skills, and their ability to listen critically.	– University-based speaking clubs contribute to the improvement of students' critical thinking and delivery skills. –Inter-university debate tournaments teach participants to locate evidence rapidly and argue their claims effectively.
Role Models	Teachers and parents who demonstrate exemplary communication habits help young individuals internalize polite, ethical, and constructive speech practices.	– A parent who consistently uses polite expressions such as "please" and "thank you" fosters positive communication habits in children. – A teacher who interacts respectfully with students models appropriate and constructive communication behavior.
Practice and Feedback	Continuous practice combined with constructive feedback enables learners to recognize shortcomings and progressively strengthen their communication competencies.	– Delivering presentations at student conferences and receiving instructor feedback increases speech clarity and self-confidence. – Comments provided during group-based projects allow students to identify weaknesses and work toward improvement.
Group Work and Collaborative Projects	Collaborative tasks encourage teamwork, negotiation, and effective communication while helping students practice expressing and organizing ideas collectively.	– Group tasks in academic courses promote productive interaction among team members. – Preparing joint presentations allows students to refine public speaking and cooperation skills.
Online Courses and Interactive Platforms	Digital tools and self-paced learning environments support independent practice and allow students to evaluate and improve their communication performance.	– Online public-speaking modules provide opportunities to practice speeches and receive automated or peer feedback. – Interactive platforms that allow recording and reviewing one's own speech help students analyze mistakes and track overall progress.
Psychological Training and Coaching	Programs focused on emotional resilience help learners overcome anxiety, build confidence, and engage more effectively with audiences.	– Workshops on coping with stress during presentations help students manage nervousness. – Individual coaching sessions strengthen communication competence and teach effective audience engagement strategies.

Conclusion

Speech etiquette and communication culture represent significant markers of a modern student's overall development. The ability to speak clearly and respectfully, demonstrate polite and thoughtful interaction, and engage in attentive listening plays a crucial role not only in academic achievement but also in students' social and professional success. Both scholarly research and practical examples confirm that these competencies are attainable and can be continuously strengthened.

It must be acknowledged that the cultivation of communication skills requires consistent effort, ongoing practice, and willingness to receive and apply constructive feedback. Participation in trainings, public speaking clubs, group-based activities, as well as observing effective behavior from role models, all contribute to the steady enhancement of students' communicative abilities. Likewise, reflecting on personal experiences—learning from achievements as well as shortcomings—further develops confidence, adaptability, and competence across various communicative situations.

In conclusion, nurturing a strong communication culture and mastering speech etiquette are essential aspects of both personal and professional growth. These competencies equip students with greater opportunities to realize their potential and integrate successfully into contemporary society. Ultimately, well-developed communication skills do more than support academic and career accomplishments—they also facilitate respectful, meaningful, and efficient interactions in all spheres of life.

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TECHNICAL SCIENCES

МЕТОДИКА ЕКСПЕРИМЕНТАЛЬНИХ ДОСЛІДЖЕНЬ ВЛАСТИВОСТЕЙ ПОКРИТТІВ ДЛЯ ПІДЛОГ ЗА ПОКАЗНИКОМ ЩОДО ПОШИРЮВАННЯ ПОЛУМ'Я

Климась Р.В.
Інститут наукових досліджень з цивільного захисту НУЦЗ України (м. Київ, Україна), заступник начальника науково-дослідного центру, кандидат технічних наук, старший дослідник
Добростан О.В.
Інститут наукових досліджень з цивільного захисту НУЦЗ України (м. Київ, Україна), начальник науково-дослідного центру, кандидат технічних наук, старший дослідник

METHOD OF EXPERIMENTAL STUDIES OF PROPERTIES OF FLOOR COATINGS IN TERMS OF FLAME SPREAD

Klymas R.
Institute of Scientific Research on Civil Protection of the NUCP of Ukraine (Kyiv, Ukraine), Deputy Head of the Research Centre, Cand. of Sc. (Eng.), Senior Research Fellow
Dobrostan O.
Institute of Scientific Research on Civil Protection of the NUCP of Ukraine (Kyiv, Ukraine), Head of the Research Center, Cand. of Sc. (Eng.), Senior Research Fellow
DOI: 10.5281/zenodo.18081885

Анотація

Проаналізовано існуючі підходи до оцінювання пожежної небезпеки покриттів для підлог. Показано доцільність запровадження в Україні європейської пожежної класифікації щодо реакції на вогонь покриттів для підлог. Відзначено роботу по створенню випробувального обладнання для визначення поведінки покриттів для підлог з використанням джерела теплового випромінювання, що дає змогу здійснювати випробування зразків усіх типів покриттів для підлог. Розроблено методику експериментальних досліджень властивостей покриттів для підлог за показником щодо поширювання полум'я. Методика дозволяє виявити закономірності зміни параметрів процесу поширювання полум'я по поверхні покриттів для підлог в умовах впливу джерела теплового випромінювання.

Abstract

Analyzed the existing approaches to assessing the fire safety of floor coatings. The expediency of implementing the European fire classification in Ukraine regarding the reaction to the fire of floor coatings has been show. The work on the creation was noted of test equipment to determine the behavior of floor coatings with the using thermal radiation source, which makes it possible to test the characteristics of all types of floor coatings. The methods of experimental studies have been developed of properties of floor coatings in terms of flame spread. The method makes it possible to identify patterns of changes in parameters in the process of spread fire on the surface of floor coatings in conditions of the thermal radiation source.

Ключові слова: пожежна небезпека, покриття для підлог, поширення вогню.

Keywords: fire hazard, floor coatings, spread of fire.

Вступ

Визначення пожежонебезпечних властивостей покриттів для підлог щодо поширювання полум'я має особливе місце у забезпеченні пожежної безпеки будівель і споруд різного функціонального призначення, а застосовні методи випробувань для їхнього оцінювання мають удосконалюватися шляхом впровадження відповідних європейських підходів.

В Україні основі вимоги пожежної безпеки до покриттів для підлог викладено в ДБН В.1.1-7 [1], відповідно до яких для матеріалів, що застосовуються в якості покриттів для підлог, повинні визначатися такі показники пожежної небезпеки: група горючості, група поширення полум'я, група займистості, коефіцієнт димоутворення, токсичність продуктів горіння.

Удосконалення національної нормативної бази, що регламентує вимоги пожежної безпеки до будівельних конструкцій, виробів і матеріалів, створення передумов для підвищення рівня їхньої пожежної безпеки на теперішній час базується на запровадженні в Україні європейської пожежної класифікації будівельних виробів і конструкцій, що встановлена у серії європейських стандартів.

У країнах Європейського Союзу до покриттів для підлог встановлені вимоги з пожежної безпеки щодо їх реакції на вогонь, а одним із основних методів для оцінювання реакції на вогонь покриттів для підлог є визначення їхньої поведінки під час

горіння з використанням джерела теплового випромінювання.

Пожежну класифікацію щодо реакції на вогонь покриттів для підлог регламентує ДСТУ EN 13501-1 [2]. Для встановлення цієї класифікації необхідно проведення випробувань щодо визначення поведінки покриттів для підлог під час горіння з використанням джерела теплового випромінювання згідно з ДСТУ EN ISO 9239-1 [3].

Тому запровадження в Україні європейського методу випробувань покриттів для підлог щодо поширювання полум'я в умовах впливу джерела теплового випромінювання згідно з ДСТУ EN ISO 9239-1 [3] є актуальною науково-технічною задачею.

Першочерговими слід вважати роботи, спрямовані на оцінку стійкості покриттів для підлог до вогневого впливу за європейською класифікацією, для чого необхідно створити відповідне випробувальне обладнання, провести його верифікацію й експериментальні дослідження низки покриттів для підлог, а отримані за цими випробуваннями результати порівняти з даними, одержаними за відповідним національним методом випробування.

Тож одним із етапів цього є розроблення методики експериментальних досліджень властивостей покриттів для підлог за показником щодо поширювання полум'я в умовах вогневого впливу за європейським методом.

Аналіз літературних даних та постановка проблеми

Аналіз нормативної бази в галузі будівництва показав, що в Україні вимоги пожежної безпеки до покриттів для підлог викладено в таких державних будівельних нормах, як ДБН В.1.1-7 [1], ДБН В.2.2-9 [4], ДБН В.2.2-41 [5], ДБН В.2.2-16 [6], ДСТУ 9192 [7]. Встановлено, що ці вимоги стосуються покриттів для підлог, що застосовуються на шляхах евакуації, а відповідність цим вимогам необхідно визначати шляхом випробувань на такі показники пожежної небезпеки, як група горючості, група займистості, група поширення полум'я, коефіцієнт димоутворення, токсичності продуктів горіння.

Пожежну класифікацію щодо реакції на вогонь покриттів для підлог, запроваджену в Європейському Союзі, регламентує ДСТУ EN 13501-1 [2]. Для встановлення цієї класифікації необхідно проведення випробувань згідно з ДСТУ EN ISO 9239-1 [3].

Також виявлено, що у підходах до оцінювання пожежної небезпеки покриттів для підлог в Україні, крім оцінювання поведінки матеріалу під час їх горіння (показників горючості, поширення полум'ям, займистості та димоутворення), також оцінюють токсичність продуктів горіння. Натомість в Європейському Союзі визначення показника токсичності продуктів горіння покриттів для підлог не проводять.

Проведений аналіз наукових праць показав, що саме питанням поширення полум'я та розповсюдження горіння по поверхні матеріалів упродовж останніх 20-30 років приділяється неабияка увага вітчизняних і закордонних вчених.

Так, ще 25 років тому в роботі [8] Коньшиним А.В. розглянуто підходи до експериментальних досліджень і математичного моделювання процесу поширення полум'я по поверхні твердих матеріалів; за результатами проведеного аналізу виявлено недоліки існуючих на той час методів. Існуючі експериментальні методи досліджень процесу поширення полум'я умовно ним поділено на дві групи: перша група методів дає можливість оцінити поведінку матеріалів у разі дії на них тільки відкритого вогню з застосуванням різноманітних джерел запалювання, а друга група методів передбачає комплексний вплив радіаційного теплового потоку та відкритого полум'я на матеріал, що дає змогу моделювати умови реальної пожежі.

Другу групу методів дослідження матеріалів на поширення полум'я по поверхні поділено на три підгрупи: натурні, масштабні та лабораторні випробування. Зазначено, що натурні методи передбачають проведення вогневих випробувань на реальних об'єктах (будівлях і спорудах) чи їх фрагментах, а їх реалізація є дороговартісною, у зв'язку з чим вони рідко використовуються на практиці. Масштабні методи випробувань моделюють процеси виникнення пожежі та поширення полум'я по поверхні оздоблювальних матеріалів у приміщенні (чи групі приміщень). В Європі того часу масштабні методи значного поширення не набули. Перша спроба розробити метод, який би моделював поширення полум'я по оздоблювальних матеріалах та забезпечував визначення небезпечних чинників пожежі була зроблена в міжнародному стандарті *ISO 9705-93 Fire Tests – Full-scale room test for surface products*; він дозволяв визначити кількісні й якісні характеристики поширення полум'я по оздоблювальних матеріалах і міг служити для обґрунтування лабораторних методів випробувань, таких як випробування на займистість і швидкість поширення полум'я. Лабораторні методи визначення параметрів поширення полум'я по поверхні оздоблювальних матеріалів стін, стель, підлог передбачають спільну дію на зразки матеріалу зовнішнього теплового випромінювання та джерела запалювання. Як засоби зовнішнього теплового випромінювання застосовують радіаційні панелі, що забезпечують вплив на матеріал густини теплового потоку, який виникає під час пожежі; як джерела запалювання зазвичай застосовують різноманітні газові пальники. В країнах колишнього Радянського Союзу для оцінки поширення полум'я по поверхні матеріалів застосовували метод експериментального визначення індексу поширення полум'я, наведений в *ГОСТ 12.1.044-89. ССБТ. Пожаровзрывоопасность веществ и материалов. Номенклатура показателей и методы их определения*, суть якого полягає в оцінюванні здатності матеріалу займатися, виділяти тепло та поширювати полум'я по поверхні за умови дії зовнішнього теплового потоку. У світі найбільшого поширення набув метод, розроблений за міжнародним стандартом *ISO 9239-1:1997 Reaction to fire tests – Horizontal surface spread of flame on floor-coverings systems – Part 1: Flame spread using a radiant heat*

ignition source, суть якого полягає у визначенні критичної щільності теплового потоку, за якої має місце поширення полум'я по поверхні матеріалу при одночасній дії на горизонтально розташований зразок теплового потоку від радіаційної панелі і джерела запалювання (газового пальника).

За результатами проведеного аналізу для визначення швидкості поширення полум'я по поверхні твердих матеріалів Коньшин А.В. запропонував об'єднати теоретичні підходи й експериментальні дослідження, що моделюють реальні умови пожежі та застосування матеріалу.

У праці [9] авторами звернули увагу, що два десятиліття тому в нормативних документах з питань пожежної безпеки у будівництві сфера застосування будівельних матеріалів визначалася, як правило, за одним показником – горючістю, а неврахування таких показників пожежної небезпеки як димоутворювальна здатність, токсичність продуктів горіння, займистість під впливом теплового потоку, здатність матеріалів поширювати полум'я по поверхні, у випадку пожежі призводить до загибелі людей і значних матеріальних збитків.

Також у роботі наведено результати експериментальних досліджень по визначенню поширення полум'я по поверхні покриттів для підлог і покрівельних матеріалів, отримані на створеному випробувальному обладнанні. Причому, дослідження по визначенню групи поширення полум'я по поверхні матеріалів для підлог проводилася на зразках, що згідно з п. 4.3 *ГОСТ 12.1.044-89. ССБТ. Пожаровзрывоопасность веществ и материалов. Номенклатура показателей и методы их определения* були віднесені до горючих матеріалів середньої займистості (підлога з деревини, наливні підлоги, килимові покриття) та важкогорючих матеріалів (композиція епоксидна модифікована «Депоксил» марки «А» типу 2 і марки «Б» типу 2).

Результати досліджень по визначенню поширення полум'я покриттів для підлог зведені в узагальнену таблицю, в якій зазначено середню довжину поширення полум'я по поверхні матеріалу ($L_п$), час від початку випробувань до займання матеріалу ($\tau_з$), тривалість полуменевого горіння ($\tau_г$).

Результати досліджень показали, що окремі типи килимових покриттів мають підвищену небезпеку в умовах пожежі, якщо вони не наклеєні на негорючу основу.

У роботі [10] за результатами проведеного аналізу посилань у нормативних документах у галузі будівництва на показники пожежної небезпеки речовин і матеріалів показано майже відсутність практичного відображення вимог до виготовлення, транспортування, зберігання та використання речовин і матеріалів залежно від їх показників пожежної небезпеки, за винятком показника групи горючості, не врахування яких може призвести у випадку пожежі до значних матеріальних збитків і загибелі людей. Із понад 400 нормативних документів, що в тій, чи іншій мірі стосуються забезпечення пожежної безпеки, було виокремлено 48 основних, аналіз яких показав мінімальну кількість вимог до виготовлення, транспортування, зберігання та використання речовин і матеріалів залежно від таких показників пожежної небезпеки, як коефіцієнт димоутворення, токсичність продуктів згоряння, займистість матеріалів, поширення полум'я, що свідчить про потребу у комплексному підході до визначення пожежонебезпечності речовин і матеріалів. Зокрема, в 48 розглянутих нормативних документах міститься лише 13 посилань на такий показник пожежної небезпеки, як поширення полум'я, що зустрічається лише в 6 із них.

У роботі [11] Долішнього Ю.В. наведено результати експериментальних досліджень димоутворення будівельних матеріалів під впливом теплових потоків різної густини, які свідчать про те, що на газодинамічний процес димоутворення горючих будівельних матеріалів впливає рівень густини теплового потоку, що діє на поверхню зразків. Досліджуючи вплив густини теплового потоку на димоутворювальну здатність будівельних матеріалів на 6 експериментальних зразках, отримано залежності коефіцієнта димоутворення від густини теплового потоку, що діє на поверхню зразків, з яких 4 – були покриттями для підлог. Встановлено, що для всіх будівельних матеріалів, що піддавалися дослідженню, зі збільшенням густини теплового потоку коефіцієнт димоутворення зростав, зокрема для ПВХ-покриття для підлоги «Sarlon Tech» виробництва фірми «Forbo» (Франція) в умовах впливу теплового потоку від 20 кВт/м^2 до 45 кВт/м^2 коефіцієнт димоутворення зростав у 2,3 рази, а для ПВХ-покриття для підлоги «Magmum Quattro» виробництва фірми «Lentex S.A.» (Польща) – в 2,1 раза.

Дослідженню пожежної небезпеки полімерних оздоблювальних матеріалів згідно з вимогами *ДБН В.1.1-7-2002 Захист від пожежі. Пожежна безпека об'єктів будівництва* присвячено роботу [12], зокрема визначено пожежонебезпечні властивості 21-го полімерного матеріалу, що застосовують у поверхневих шарах покриттів підлог приміщень громадських будинків із масовим перебуванням людей за їх групою горючості, займистості та поширення полум'я.

За результатами проведених досліджень встановлено, що килимові покриття для підлог, виготовлені із натуральних і синтетичних матеріалів, або комбінацій цих матеріалів, належать до групи горючості Г4 (підвищеної горючості): на 3-4 хвилинах від початку їх випробувань температура летких продуктів горіння перевищувала 450 °С, відбувалося повне згоряння зразків і виникала необхідність їх примусового гасіння. Разом із тим, зазначені килимові покриття, що належать до матеріалів групи займистості В2 (середньої займистості) та груп поширення полум'я РП1 (не поширюють полум'я) або РП2 (локально поширюють полум'я), можуть бути застосовані для покриттів підлог в коридорах, холах, фойє. Покриття підлог на основі ПВХ або каучуку суттєво відрізняються за показником горючості: від групи Г1 (низької горючості) до групи Г4 (підвищеної горючості); з урахуванням показників займистості та поширення полум'я ці покриття

підлог дозволяється застосовувати на шляхах евакуації в громадських будинках.

У роботі [13] Лавренюком О.І. досліджено вплив вмісту кварцового піску на фізико-механічні властивості покриттів.

На основі експериментальних даних показана перспективність використання мінеральних наповнювачів для зниження горючості модифікованих полівінілпіролідоном епоксиамінних композицій для наливних підлог; розроблено рецептури композицій на базі епоксидних смол для одержання монолітних покриттів із пониженою горючістю та поліпшеними експлуатаційними характеристиками. Експериментально визначено показники пожежної небезпеки одержаних епоксиполімерів. Встановлено, що максимальна температура газоподібних продуктів горіння становила 203 °С, а час досягнення максимальної температури – 320 с; втрата маси зразків на основі модифікованої полівінілпіролідоном епоксиамінної композиції з додатками кварцового піску дорівнювала 33 %, а середня температура займання – 305 °С.

Авторським колективом у роботі [14] проаналізовані європейські (міжнародні) нормативні документи, в яких регламентовані вимоги щодо пожежної класифікації та методів випробувань із визначення показників пожежної небезпеки будівельних матеріалів і виробів. Згідно з європейською класифікацією будівельні вироби та матеріали поділяються на три групи, в одну із яких виокремлено покриття для підлоги, причому для них використовують додаткову класифікацію по димоутворенню (*s1, s2*).

За результатами аналітичних досліджень обґрунтовано необхідність адаптації національної пожежно-технічної класифікації будівельних матеріалів і виробів з європейською пожежною класифікацію; зокрема виявлено основні шляхи адаптації, що полягають, у т.ч. в розробленні національних стандартів, гармонізованих з такими європейськими стандартами, що встановлюють вимоги до пожежної класифікації та методів визначення показників пожежної небезпеки будівельних матеріалів і виробів, серед яких також зазначався *EN ISO 9239-1:2010 Reaction to fire tests for floorings – Part 1: Determination of the burning behaviour using a radiant heat source* (Випробування покриттів для підлог щодо реакції на вогонь. Частина 1. Визначення поведінки під час горіння з використанням джерела теплового випромінювання).

Повномасштабним випробуванням на вогнестійкість систем підлог з легких сталевих каркасів присвячена робота [15]. Це дослідження показало, що додавання додаткового 16-міліметрового шару гіпсокартону до неізольованої конструкції підвищило рівень вогнестійкості на 66 %, а використання сталево-бетонного композитного настилу підлоги підвищило рівень вогнестійкості на 32 %. У ньому наведено дані про температуру та час відшарування гіпсокартону для розробки критерію відшарування в чисельних дослідженнях. Результати дослідження показали, що випробування на вогнестійкість з коротким прольотом, хоча і є консервативними з погляду часу руйнування, дають результати, порівнянні з результатами повномасштабних стандартних випробувань на вогнестійкість, що свідчить про їх економічну ефективність та економію часу під час перевірки вогнестійкості наявних і нових конструкцій перекриття. Це дослідження надало відповідні рекомендації щодо проєктування, включно з рівнями вогнестійкості 16 конфігурацій підлоги зі сталевих легких каркасів, що є цінним орієнтиром для пожежних інженерів.

У статті [16] наведено порівняння поведінки під час горіння килимів, виготовлених із різних волокон або сумішей, оцінених за допомогою тесту з використанням таблетки метенаміну, вертикального тесту на вогнестійкість F.A.R., британського тесту з використанням радіаційної панелі та французького тесту Epiradia Teur, показує, що вовна, а особливо вовна з підвищеною вогнестійкістю, демонструє значно кращі результати, ніж інші досліджувані штучні волокна, особливо в більш суворих вертикальних тестах і тестах з використанням радіаційної панелі. Відповідно до випробувань, основа килима повинна бути вогнестійкою, щільність вогнестійкого вовняного ворсу – вище 0,10 г/см² (0,058 г/дюйм²), а вага та товщина ворсу не повинні перевищувати певного значення для забезпечення ефективного відведення тепла від ворсу, гарантуючи коротке поширення полум'я.

Досліджуючи реакцію покриттів для підлог на вогонь Melisa Pinton з Міжнародного університету Бурча (Сараєво, Боснія і Герцеговина) окреслює динамічну взаємодію між естетикою, функціональністю та вогнестійкістю в архітектурних просторах. Її робота [17] присвячена всебічному огляду різних типів підлогових покриттів, підкреслюючи їх унікальні властивості та внесок у забудову. У контексті вогнестійкості вона розглядає нюанси реакції різних підлогових покриттів на вогонь. Зокрема, дослідження твердої деревини та ламінату підкреслило відмінності між масивною й інженерною твердою деревиною, вразливість твердої деревини у разі пожежі та подвійну природу стійкості та вразливості ламінату. Вінілове покриття виявилося природно вогнестійким, але з потенційними небезпеками, пов'язаними з токсичними випарами. Килими, з їх різним складом волокон, потребували обробки вогнезахисними засобами для підвищення вогнестійкості. Керамічна та порцелянова плитка зарекомендували себе як зразки вогнестійких підлогових покриттів, що за своєю природою є негорючими і здатні витримувати високі температури без виділення шкідливих речовин. Відмічено важливу роль клеїв, оздоблювальних матеріалів і додаткових оброблень у підвищенні пожежної безпеки підлогових покриттів.

У статті [18] розглядається пожежна безпека гумового покриття, що використовується в центрі зимових видів спорту в Китаї. Характеристики та параметри горючості гумового покриття для підлоги було визначено за допомогою випробувань матеріалу на вогнестійкість. Згодом було проведено аналіз пожежної безпеки з використанням методу іскробезпечності. Крім того, було проведено

чисельне моделювання для дослідження сценаріїв пожежі й евакуації людей, зокрема у випадках, коли рівень безпеки матеріалів оздоблення підлоги не відповідає стандартним вимогам. Результати показують, що за певних умов безпеки центр зимових видів спорту може використовувати гумове покриття класу В1 у необхідній зоні, забезпечуючи водночас дотримання стандартів пожежної безпеки.

У роботі [19] авторським колективом показано актуальність випробувань з визначення поведінки покриттів для підлог під час горіння з використанням джерела теплового випромінювання. Підтверджено доцільність запровадження в країні європейської пожежної класифікації щодо реакції на вогонь покриттів для підлог. Уперше в Україні на рівні європейських підходів розроблено конструкцію та робочу конструкторську документацію випробувального обладнання для визначення поведінки покриттів для підлог під час горіння з використанням джерела теплового випромінювання. Обґрунтовано й експериментально підтверджено параметри пальника для запалювання зразка, радіаційної панелі та системи для вимірювання оптичної густини диму. Технічні характеристики створеного випробувального обладнання дають змогу здійснювати випробування зразків всіх типів покриттів для підлог. Створене випробувальне обладнання в повній мірі дозволяє проводити випробування покриттів для підлог під час горіння з використанням джерела теплового випромінювання згідно з вимогами та методикою, наведеними в ДСТУ EN ISO 9239-1 [3].

Також сформульовано пропозиції щодо подальшого використання результатів випробувань на створеному випробувальному обладнанні щодо доцільності проведення випробування низки покриттів для підлог, результати яких можуть бути підґрунтям для розроблення та внесення відповідних змін до будівельних норм стосовно вимог до покриттів для підлог, а виробникам продукції – для розроблення нових видів і типів покриттів для підлог.

Тож, створене випробувальне обладнання дає змогу оцінити пожежну небезпеку зразків усіх типів покриттів для підлог, зокрема виявити закономірності зміни параметрів процесу поширювання полум'я по поверхні покриттів для підлог в умовах впливу джерела теплового випромінювання.

Мета і задачі досліджень

Метою даної статті є визначення основних положень методики експериментальних досліджень властивостей покриттів для підлог за показником щодо поширювання полум'я.

Кінцевою метою експериментальних досліджень є верифікація методу випробувань покриттів для підлог на поширювання полум'я в умовах впливу джерела теплового випромінювання згідно з ДСТУ EN ISO 9239-1 [3].

Для досягнення поставленої мети необхідно розв'язати такі задачі:

– визначити тип і кількість необхідних засобів вимірювальної техніки;

– провести верифікацію створеного випробувального обладнання [20] щодо відповідності його параметрів (лінійних розмірів, взаємного розташування його елементів тощо) та метрологічних показників засобів вимірювальної техніки вимогам, наведеним в ДСТУ EN ISO 9239-1 [3], а також здатності здійснювати номінальний тепловий вплив на зразки покриттів для підлог під час випробування;

– визначити властивості покриттів для підлог, що широко застосовують під час будівництва, за показником щодо поширювання полум'я в умовах впливу джерела теплового випромінювання шляхом випробування згідно з ДСТУ EN ISO 9239-1 [3];

– визначити повторюваність результатів випробувань, отриманих із застосуванням створеного обладнання, й оцінити її відповідність даним, наведеним в таблиці В ДСТУ EN ISO 9239-1 [3];

– узагальнити та систематизувати отримані експериментальні дані та виявити закономірності щодо параметрів процесу поширювання полум'я по поверхні покриттів для підлог в умовах впливу джерела теплового випромінювання.

Виклад основного матеріалу

Сутність методу експериментальних досліджень полягає у виявленні закономірностей зміни параметрів процесу поширювання полум'я по поверхні покриттів для підлог в умовах впливу джерела теплового випромінювання, а також визначення властивостей за показником поширювання полум'я покриттів для підлог, що широко застосовують під час будівництва.

Експериментальні дослідження проводять за таких умов оточуючого середовища в приміщенні, в якому встановлено випробувальне обладнання:

– температура повітря: від 10 ºС до 30 ºС;

– відносна вологість повітря: від 40 % до 80 %;

– атмосферний тиск від 84,0 кПа до 106,7 кПа.

Для проведення експериментальних досліджень застосовують випробувальне обладнання [19, 20], створене відповідно до вимог ДСТУ EN ISO 9239-1 [3], та засоби вимірювальної техніки, характеристики яких наведено в табл. 1.

Таблиця 1

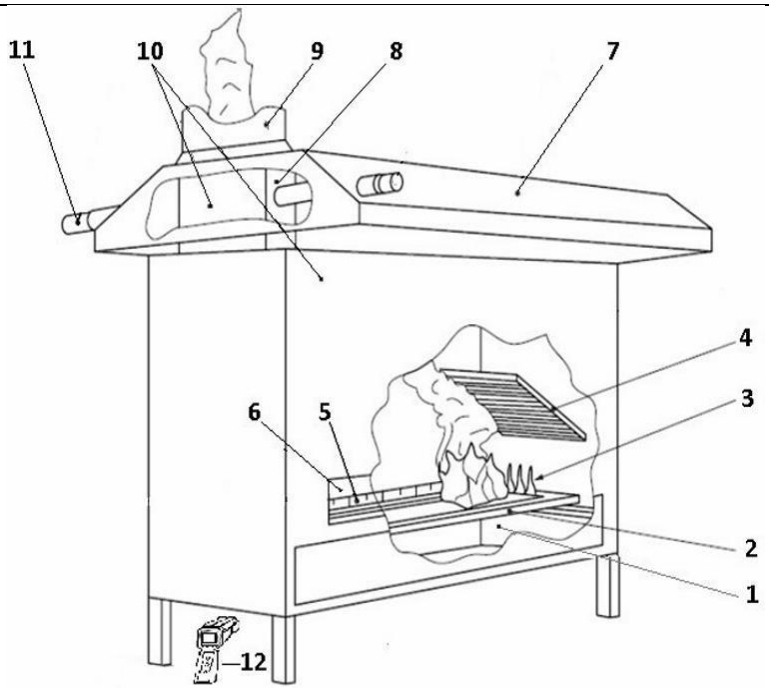
Характеристики засобів вимірювальної техніки

Найменування ЗВТ	Заводський номер		
		діапазон вимірювання	клас точності ЗВТ, невизначеність / похибка
Інформаційно-вимірювальна система «Термоконт»	б/н	реєстрація температури	
		від 0 °С до 1200 °С	U = 0,14 °С / Δ = ± 0,35 %
Анемометр цифровий AR856	990	вимірювання швидкості вітру	
		від 0,3 м/с до 45 м/с	U = 0,82 м/с / Δ = ± 0,2 м/с
Барометр-анероїд М67	716	вимірювання атмосферного тиску	
		від 610 мм рт. ст. до 790 мм рт. ст.	U = 0,6 мм рт. ст. / Δ = ± 1 мм рт. ст.
Лінійка вимірювальна металева	45	вимірювання лінійних розмірів	
		від 0 до 1000 мм	2 клас точності; U = 0,598 мм / Δ = ± 1,0 мм
Перетворювачі термоелектричні ТХА	б/н	вимірювання температури	
		від 0 до 333 °С; від 334 °С до 1200 °С	U = 1,5 °С / Δ = ± 2,5 °С U = 3,08 °С / Δ = ± 0,0075·$T_{вим}$ °С
Секундомір СОС пр 2Б-2-010	4693	вимірювання часу	
		від 0 до 3600 с; від 0 до 60 с; більше 60 с	2 клас точності; U = 0,24 с / Δ = ± (0,4·τвим / 60) с Δ=±(0,4+1,5·(τвим -60)/3540) с
Термогігрометр “Testo” 608-H1	45038120	вимірювання температури та вологості	
		від 0 до 50 ºС від 2 % до 98 %	U = 0,4 ºС / Δ = ± 0,5 ºС U = 1,2 % / Δ = ± 3 %
Штангенциркуль ШЦЦП-1-150-0,005	16128265	вимірювання товщини	
		від 0 до 150 мм	U=0,00697 мм / Δ = ± 0,005 мм

Створене «Обладнання для визначення поведінки покриттів для підлог під час горіння з використанням джерела теплового випромінювання» призначене для випробувань зразків покриттів для підлог усіх типів, наприклад текстильних килимів, килимів, виготовлених із корки, деревини, гуми та пластмас, а також зовнішніх шарів методом оцінювання поведінки під час горіння в умовах, коли поширюванню полум’я заважає повітряний потік, а також поширювання полум’я горизонтально змонтованими підлогами, що зазнають впливу градієнта щільності теплового потоку у випробувальній камері під час запалювання полум’ям від пальника для запалювання; за потреби, на цьому обладнанні може бути проведене оцінювання димоутворення покриттів для підлог в умовах вогневого впливу.

Схему випробувального обладнання наведено на рис. 1.

Загальний вигляд створеного випробувального обладнання наведено на рис. 2.



1 – випробувальна камера; 2 – утримувач зразка разом зі зразком на зсувній платформі; 3 – пальник для запалювання зразка; 4 – радіаційна газова панель; 5 – шкала; 6 – відкидні дверцята; 7 – витяжний зонт; 8 – витяжна труба випробувальної камери; 9 – витяжний трубопровід системи відведення димових газів; 10 – термопари; 11 – система для вимірювання оптичної густини диму; 12 – радіаційний пірометр

Рис. 1. Схема випробувального обладнання

Рис. 2. Загальний вигляд випробувального обладнання

Для визначення повторюваності результатів випробувань, отримуваних із застосуванням створеного обладнання за стандартною процедурою випробування, встановленою п. 8.2 ДСТУ EN ISO 9239-1 [3], проводять випробування покриттів для підлог п’яти типів, вибраних із тих, що наведені в табл. 2 (ця таблиця відповідає табл. В.1 ДСТУ EN ISO 9239-1 [3], яку підготовлено у процесі розробляння стандарту EN ISO 9239-1:2010 за результатами проведення

міжлабораторних випробувань 10 покриттів для підлог, в якому брали участь 13 лабораторій).

Таблиця 2

Результати міжлабораторних випробувань

Тип покриття для підлоги	Щільність теплового потоку HF-30 кВт/м^2	Повторюваність		Відтворюваність	
		стандартний відхил S_r кВт/м^2	$100S_r/m^a$ %	стандартний відхил S_R кВт/м^2	$100S_R/m$ %
Деревостружкова плита, необроблена антипіренами	4,4	0,1	3,4	0,6	12,6
Березовий паркет	7,8	1,6	19,9	1,9	24,7
ПВХ, суцільний вініл	10,7	0,2	2,3	0,6	5,6
Гума	6,4	0,8	13,0	1,5	23,9
Поліамідний килим (з текстильною основою)	3,8	0,4	10,5	0,8	21,3
Поліамідний килим (з текстильною основою, обробленою антипіренами)	7,6	1,1	14,8	1,8	23,6
Поліамідний килим (з латексною основою)	3,7	0,8	20,5	1,0	27,1
Поліпропіленовий килим	2,7	0,2	6,5	0,4	13,4
Поліпропіленовий килим (з голкопробивною повстю)	5,2	1,1	21,4	2,4	47,2
Килим з шерсті / поліаміду (80/20)	7,8	0,8	10,0	1,5	18,9
[a] m — статистичне середнє					

Для кожного з п’яти вибраних з табл. 2 покриттів для підлог виконують по п’ять повторювальних випробувань. Для кожного з цих п’яти повторювальних випробувань за стандартною процедурою, поданою в п. 8.2 ДСТУ EN ISO 9239-1 [3], проводять випробування трьох однакових зразків за однакового орієнтування (для першого з п’яти повторювальних випробувань ще проводять випробування одного зразка за іншого орієнтування), за результатами яких визначають три значення щільності теплового потоку HF-30 (кВт/м^2), яку сприймає зразок покриття у точці найдальшого поширення полум’я, що спостерігається впродовж перших 30 хв випробування. Розраховують середнє значення щільності теплового потоку HF-30 для цих трьох зразків за однакового орієнтування, яке приймають за результат одного з п’яти повторювальних випробувань. Для кожного з п’яти обраних з табл. 2 покриттів для підлог за стандартною процедурою, поданою в п. 8.2 ДСТУ EN ISO 9239-1 [3], випробовують 16 зразків і для п’яти повторювальних випробувань визначають середні значення щільності теплового потоку $(HF\text{-}30)_1$, $(HF\text{-}30)_2$, $(HF\text{-}30)_3$, $(HF\text{-}30)_4$, $(HF\text{-}30)_5$. Для кожного з п’яти обраних з табл. 2 покриттів для підлог за формулою (1) обчислюють середню величину щільності теплового потоку $(HF\text{-}30)_{ave}$ (кВт/м^2) і за формулою (2) визначають стандартний (середнє квадратичний) відхил S_{measur}.

$$(HF\text{-}30)_{ave} = ((HF\text{-}30)_1 + (HF\text{-}30)_2 + (HF\text{-}30)_3 + (HF\text{-}30)_4 + (HF\text{-}30)_5)/5 \quad (1)$$

$$S_{measur} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(y_i - \bar{y})^2}, \quad (2)$$

де: y_i – середнє значення щільності теплового потоку HF-30 для певного випробування;

$\bar{y}$ – середня величина щільності теплового потоку $(HF\text{-}30)_{ave}$;

n – кількість випробувань, $n = 5$.

Отримані для кожного з п’яти покриттів значення $100S_{measur}/(HF\text{-}30)_{ave}$ порівнюють з величинами $100S_r/m$, наведеними в табл. 2. У разі, якщо $100S_{measur}/(HF\text{-}30)_{ave}$ не перевищує $100S_r/m$, вважають, що повторюваність результатів випробувань, отримуваних із застосуванням створеного обладнання, задовільно відповідає даним, наведеним в табл. В.1 ДСТУ EN ISO 9239-1 [3]. У разі, якщо $100S_{measur}/(HF\text{-}30)_{ave}$ перевищує $100S_r/m$ не більше ніж у два рази, цю відповідність вважають сумнівною. У разі, якщо $100S_{measur}/(HF\text{-}30)_{ave}$ перевищує $100S_r/m$ більше ніж у два рази, вважають, що повторюваність результатів випробувань, отримуваних із застосуванням створеного обладнання, не відповідає даним, наведеним в табл. В.1 ДСТУ EN ISO 9239-1 [3].

Для кожного з п’яти обраних з табл. 2 покриттів для підлог здійснюють порівняння значення $(HF\text{-}30)_{ave}$ з середнє статистичною величиною HF-30, отриманою під час міжлабораторного випробування і наведеною в табл. 2. Для цих покриттів за формулою (3. обчислюють значення z-показника.

$$z = ((HF\text{-}30)_{ave} - HF\text{-}30)/S_R, \quad (3)$$

де HF-30 і S_R – значення, подані в табл. 2 для певного типу покриття.

Згідно з п. 4.1.1 ДСТУ EN ISO/IEC 17043 [21] задовільним вважають результат порівняння, якщо $|z|$ є меншим 2. Якщо значення $|z|$ знаходиться в межах від 2 до 3, результат вважають сумнівним, а якщо більше 3 – незадовільним.

У разі отримання незадовільних результатів, необхідно звернути увагу на:

– однорідність зразка та процедуру його підготовки;

– компетентність персоналу;

– умови проведення випробування;

– справність обладнання, достовірність даних щодо його калібрування.

Після виявлення невідповідностей необхідно провести їх усунення та провести повторні випробування.

Для визначення повторюваності результатів випробувань, отримуваних із застосуванням створеного обладнання, а також порівняння отриманих результатів з даними міжлабораторних випробувань, поданими в табл. В.1 ДСТУ EN ISO 9239-1 [3], можуть використовуватись типи покриттів для підлог, що широко застосовують під час будівництва. Для оцінювання властивостей широко застосовних покриттів для підлог, якщо їх тип відрізняється від типів, поданих в табл. 2, необхідно проводити визначальні випробування згідно з ДСТУ EN ISO 9239-1 [3].

Під час узагальнення та систематизації отриманих експериментальних даних і виявлення закономірностей щодо параметрів процесу поширювання полум'я по поверхні покриттів для підлог в умовах впливу джерела теплового випромінювання згідно з ДСТУ EN ISO 9239-1 [3] використовують результати проведених повторювальних випробувань і визначальних випробувань, у разі їхнього проведення. Визначають залежності щільності теплового потоку, яку сприймають покриття у точці найдальшого поширення полум'я, від тривалості теплового впливу в умовах, встановлених у ДСТУ EN ISO 9239-1 [3].

Висновки

Таким чином, представлена методика експериментальних досліджень властивостей покриттів для підлог за показником щодо поширювання полум'я дає змогу провести верифікацію методу випробувань покриттів для підлог на поширювання полум'я в умовах впливу джерела теплового випромінювання згідно з ДСТУ EN ISO 9239-1 [3] та, провівши оцінювання окремих типів покриттів для підлог, що широко застосовують під час будівництва, виявити закономірності зміни параметрів процесу поширювання полум'я по поверхні покриттів для підлог в умовах впливу джерела теплового випромінювання.

У подальшому передбачається провести оцінювання отриманих результатів експериментальних досліджень, проведених відповідно до запропонованої методики, що буде предметом наступної роботи.

Отримані результати, як один із кроків до гармонізації європейських підходів у сфері забезпечення пожежної безпеки, мають стати підґрунтям до розроблення пропозицій щодо змін у ДБН В.1.1-7 [1] в частині застосування покриттів для підлог на шляхах евакуації.

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No 175 (175) (2024)

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Frequency: 24 issues per year.
Format - A4
ISSN 9215 — 0365

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