Integrating Hygienic Chemistry Experiments with Preventive Medicine Practice: A Holistic and Innovative Pedagogical Framework

Abstract: Hygienic chemistry experimental teaching constitutes an indispensable cornerstone within the preventive medicine educational ecosystem, exerting a profound influence on the cultivation of proficient public health professionals. This paper undertakes a comprehensive and in - depth exploration, meticulously identifying and dissecting the multifaceted challenges inherent in contemporary teaching practices, with a keen focus on the practical exigencies of preventive medicine. A robust, three - dimensional reform strategy is proposed, encompassing the enhancement of curriculum content, the innovation of teaching methodologies, and the optimization of the evaluation system. The overarching objective is to forge a more profound and seamless connection between experimental learning experiences and health prevention initiatives, thereby equipping students with a dual - pronged skill set: advanced chemical analysis techniques and astute public health acumen. This strategic approach aims to provide robust support for diverse sectors, including disease prevention and control, environmental surveillance, and food safety management, ultimately contributing to the advancement of public health practice.
Keywords: Hygienic Chemistry Experiment; Preventive Medicine; Teaching Reform; Public Health Practice; Pedagogical Innovation

1.Introduction

In the intricate and evolving landscape of preventive medicine education, hygienic chemistry experiments serve as a critical nexus that bridges the gap between theoretical knowledge and practical application[1,2]. These experiments empower students to develop essential skills in detecting, analyzing, and quantifying chemical substances, while also fostering the ability to interpret experimental results within the context of health risk assessment[3,4]. As the field of public health continues to expand and diversify, encompassing areas such as environmental monitoring, food safety assurance, occupational health protection, and emerging infectious disease

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control[5], the traditional approaches to hygienic chemistry experimental teaching have increasingly shown their limitations.

Rapid advancements in analytical technologies, including the development of highly sensitive and specific detection methods[6], have transformed the capabilities of public health laboratories. For instance, the use of mass spectrometry - based techniques has enabled the identification and quantification of trace - level contaminants in environmental and biological samples[7]. Despite these technological breakthroughs, studies by Wilson and Thompson[8] and Chen et al.[9] indicate that traditional experimental curricula often fail to incorporate these modern analytical methods, leaving students ill - prepared for contemporary public health practice.

The growing complexity of public health issues, such as the emergence of novel pollutants and the increasing prevalence of chronic diseases related to environmental exposures[10,11], demands a more comprehensive and integrated approach to education. Research by White et al.[12] has highlighted the importance of equipping public health students with the skills to conduct risk assessments, develop preventive strategies, and communicate findings effectively. However, a survey by Green and Moore[13] revealed that current teaching models in hygienic chemistry experiments predominantly focus on technical proficiency, neglecting the development of these essential public health competencies.

Furthermore, the shift towards evidence - based public health practice[14] necessitates that students are trained to design and conduct experiments that generate reliable and actionable data[15]. Studies by Miller et al.[16] and Anderson et al.[17] have emphasized the need for experiential learning opportunities that simulate real - world public health scenarios, enabling students to apply theoretical knowledge in practical settings. However, the existing teaching framework, characterized by a heavy reliance on rote - learning and teacher - centered instruction[18,19], often fails to provide such opportunities.

A comprehensive reform of the hygienic chemistry experimental teaching framework is thus essential to meet these evolving demands, align teaching with contemporary public health practices, and prepare students for successful careers in the field. This reform should aim to integrate modern analytical technologies, cultivate public health - oriented thinking, and enhance students' ability to contribute meaningfully to health promotion and disease prevention efforts.

2. Challenges in Current Hygienic Chemistry Experimental Teaching

2.1 Disconnect between Curriculum Content and Practical Public Health Needs

The current curriculum of hygienic chemistry experiments is predominantly

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characterized by an overemphasis on fundamental chemical analysis techniques. Core experiments, such as acid - base titration, which focuses on the quantitative determination of reactant concentrations through volume - based measurements, and spectrophotometric analysis, which relies on the measurement of light absorption or transmission by chemical substances, have long formed the backbone of experimental instruction. While these traditional experiments are crucial for establishing a solid foundation in chemical analysis principles and laboratory skills, they often lack direct relevance to the complex and dynamic requirements of modern public health practice.

In the realm of occupational health, for example, the demand for real-time monitoring of toxic gases in industrial workplaces has become increasingly critical. Advanced analytical techniques, such as gas chromatography - mass spectrometry (GC-MS) for the identification and quantification of volatile organic compounds, and portable sensor arrays for the rapid detection of hazardous substances like benzene, formaldehyde, and ammonia, are now widely employed in occupational health surveillance. However, these cutting - edge methods are rarely integrated into the experimental curriculum, leaving students ill - prepared to address the occupational health challenges they will encounter in professional settings.

Similarly, in the context of infectious disease prevention and control, nucleic acid - based pathogen detection technologies, including polymerase chain reaction (PCR), loop - mediated isothermal amplification (LAMP), and next - generation sequencing (NGS), have revolutionized the field. These techniques enable rapid and accurate identification of infectious agents, which is crucial for timely outbreak response and containment. Nevertheless, the lack of exposure to these advanced methods in the experimental curriculum means that students are not equipped with the necessary skills to contribute effectively to epidemic prevention efforts. This disconnect between the curriculum and practical public health needs results in a significant gap in students' knowledge and skills, making it difficult for them to apply classroom - learned concepts to real - world public health work.

2.2 Insufficient Cultivation of Public Health - Oriented Thinking

The traditional teacher - centered teaching model, which has been the norm in hygienic chemistry experimental education for many years, is characterized by a didactic approach. In this model, teachers typically provide detailed instructions on experimental procedures, including the underlying principles, step - by - step protocols, and safety considerations, followed by a demonstration of the experiment. Students are then expected to replicate the experiment, often following the instructions verbatim without much room for independent thinking or exploration.

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This passive learning environment fosters rote - learning and mechanical execution of experiments, rather than encouraging students to think critically about the public health implications of their work. For instance, in a water quality testing experiment where students measure the levels of heavy metals such as lead, mercury, and cadmium in water samples using atomic absorption spectroscopy, the focus is often on the technical aspects of the analysis, such as accurate sample preparation and instrument calibration. However, students may not be guided to consider broader public health factors, such as the acceptable daily intake levels of these heavy metals for human consumption, the potential long - term health effects on vulnerable populations (such as children and the elderly) who rely on the water source, or the development of evidence - based preventive strategies to mitigate the risks associated with contaminated water.

The lack of emphasis on public health - oriented thinking not only limits students' understanding of the practical significance of their experimental work but also hinders the development of essential skills such as critical thinking, problem - solving, and decision - making, which are crucial for addressing complex public health issues. Without these skills, students will struggle to navigate the multifaceted challenges of the public health field and contribute meaningfully to health promotion and disease prevention efforts.

2.3 Ineffective and Narrow - Focused Evaluation System

The current assessment system for hygienic chemistry experiments primarily focuses on technical accuracy and the quality of laboratory reports. Technical accuracy is evaluated based on criteria such as the correct use of laboratory equipment, the precision of measurements, and adherence to experimental protocols. Laboratory reports are judged on the clarity of presentation, the accuracy of data recording, and the logical organization of experimental results and conclusions.

While these aspects are undoubtedly important, this narrow - focused evaluation framework fails to comprehensively assess several key public health competencies that are essential for professionals in the field. For example, the ability to conduct a comprehensive health risk assessment, which involves evaluating the likelihood and potential impact of chemical exposures on human health, is not adequately measured. Similarly, the skill of developing evidence - based preventive measures and intervention strategies based on experimental findings, a critical aspect of public health practice, is often overlooked.

Moreover, the current evaluation system does not provide sufficient opportunities for students to demonstrate their ability to interpret chemical data from a public health perspective, communicate their findings effectively to diverse stakeholders (including

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policymakers, healthcare providers, and the general public), and engage in evidence - informed decision - making. This one - dimensional approach to evaluation makes it difficult to accurately gauge students' overall competence in translating chemical analysis results into actionable public health solutions, thereby impeding the identification and cultivation of future public health leaders.

3. Reform Strategies Aligned with Preventive Medicine Practice

3.1 Enhancement of Curriculum Content

3.1.1 Integration of Practical and Real - World - Oriented Projects

To bridge the gap between the curriculum and public health practice, a series of innovative and practical projects have been developed and integrated into the hygienic chemistry experimental curriculum. These projects are designed to simulate real - world public health scenarios, providing students with hands - on experience in applying their chemical analysis skills to address actual public health problems.

One such project is the "Community - Based Drinking Water Microbiological and Chemical Safety Assessment." In this comprehensive project, students are tasked with collecting water samples from various sources within a local community, including municipal water supplies, wells, and storage tanks. They then employ a combination of traditional microbiological culturing techniques (such as agar plate counting for the enumeration of bacteria and fungi) and modern molecular biology methods (such as quantitative PCR for the detection of specific pathogens like Escherichia coli, Salmonella, and norovirus). Simultaneously, students analyze the chemical composition of the water samples, measuring parameters such as pH, turbidity, dissolved oxygen, and the concentrations of heavy metals (e.g., lead, arsenic, cadmium) and disinfection by - products (e.g., trihalomethanes).

After obtaining the experimental results, students conduct a detailed risk assessment, considering factors such as local water consumption patterns, the vulnerability of the population (including children, the elderly, and individuals with compromised immune systems), and relevant national and international drinking water quality standards (such as those set by the World Health Organization and the United States Environmental Protection Agency). Based on this assessment, students develop a comprehensive report that includes recommendations for improving water quality, such as enhancing water treatment processes, implementing better water storage and distribution practices, and promoting public awareness of safe drinking water. This project not only enhances students' technical skills in chemical and microbiological analysis but also instills in them a deeper understanding of the importance of water safety in public health.

Another notable project is the "Indoor Air Quality Monitoring and Intervention

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in Public Buildings." Public buildings, such as schools, hospitals, offices, and shopping malls, are environments where people spend a significant amount of time. Ensuring good indoor air quality is essential for the health, comfort, and productivity of the occupants. In this project, students use a variety of specialized equipment, including air samplers, gas detectors, and particulate matter monitors, to collect and analyze air samples from different areas within public buildings. They measure a wide range of indoor air pollutants, including carbon dioxide, carbon monoxide, formaldehyde, volatile organic compounds (VOCs), and particulate matter (PM2.5 and PM10).

Students then analyze the data in the context of relevant indoor air quality guidelines and standards, and conduct a risk assessment to determine the potential health impacts on the building occupants. Based on their findings, they develop and propose practical and feasible intervention strategies, such as improving ventilation systems, using air purifiers, and reducing the use of chemical - based cleaning products and building materials that emit harmful pollutants. This project helps students understand the complex interactions between indoor air quality, human health, and building design, and equips them with the skills to address indoor air quality issues in real - world settings.

3.1.2 Case - Based Learning Approach

Case - based learning has been introduced as an effective pedagogical strategy to enhance students' understanding of how hygienic chemistry principles and techniques can be applied to support public health decision - making. Real - world public health incidents, carefully selected for their educational value and relevance, are used as teaching cases to engage students in active learning and problem - solving.

For example, in the case of a school food poisoning outbreak, students are presented with a detailed scenario that includes information about the symptoms of the affected students, the time and place of the incident, the initial investigations conducted by public health authorities, and the suspected food items. Students are then provided with samples of the suspected foods, as well as relevant environmental samples (such as water and surface swabs from the food preparation area). Using a combination of analytical techniques, including chromatography (e.g., high - performance liquid chromatography - HPLC and gas chromatography - GC) and mass spectrometry (e.g., tandem mass spectrometry - MS/MS), students analyze the samples to detect and identify potential chemical contaminants, such as pesticides, heavy metals, food additives, or toxins produced by bacteria (e.g., mycotoxins).

Through this process, students learn how to trace the source of the contamination, whether it is due to improper food handling practices, contamination during

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production or distribution, or adulteration. They then analyze the case from a public health perspective, considering factors such as the impact of the incident on the health of the students, the school community, and the local population, as well as the broader implications for food safety regulation and public health surveillance. Students are required to develop a set of recommendations for preventing similar incidents in the future, which may include improvements in food safety education, enhanced food inspection and monitoring systems, and better communication and collaboration between schools, food suppliers, and public health agencies. This case - based learning approach not only deepens students' understanding of the practical applications of hygienic chemistry but also develops their critical thinking, problem - solving, and communication skills.

3.2 Innovation in Teaching Methodologies

3.2.1 Problem - Based Learning (PBL)

Problem - based learning (PBL) has been adopted as a central teaching methodology to foster students' independent thinking, self - directed learning, and problem - solving abilities. In the PBL approach, teaching begins with the presentation of real - life, complex public health problems related to hygienic chemistry.

For example, in the context of soil contamination in agricultural areas, students are introduced to a scenario where local farmers have reported reduced crop yields, and there are concerns about the potential health risks to the farming community due to the presence of heavy metals and other chemical pollutants in the soil. Students are then organized into small groups and tasked with formulating research questions, designing experiments, and developing strategies to address the problem. Each group is responsible for conducting a thorough literature review to gather relevant information on soil contamination, its sources, health effects, and remediation techniques.

Based on their research, students design experiments to sample the soil, select appropriate chemical analysis methods (such as atomic fluorescence spectrometry for heavy metal analysis and gas chromatography - mass spectrometry for organic pollutant analysis), and plan for data collection and analysis. During the experimental process, students encounter various challenges and obstacles, such as sample heterogeneity, interference in analytical measurements, and the need to interpret complex data. They are encouraged to work together, seek additional resources, and consult with their instructors and peers to overcome these challenges.

After completing the experiments, students analyze the data using statistical methods, interpret the results in the context of the initial problem, and draw evidence -

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based conclusions. They then present their findings and proposed solutions to the class, engaging in a constructive discussion and receiving feedback from their classmates and instructors. This PBL approach not only enables students to acquire in - depth knowledge of chemical analysis techniques but also helps them develop essential skills such as critical thinking, teamwork, communication, and the ability to apply scientific knowledge to solve real - world problems.

3.2.2 Simulation - Based Training

Simulation - based training has been introduced as an innovative teaching approach to provide students with immersive and realistic experiences in handling public health emergencies related to chemical exposures. Simulated scenarios, carefully designed to mimic the complexity, urgency, and uncertainty of real - world incidents, are used to train students in a controlled environment.

For example, in the "Emergency Response to a Chemical Spill in an Industrial Area" simulation, students are divided into several teams, each assigned specific roles and responsibilities. The environmental monitoring team is responsible for quickly assessing the extent and nature of the chemical spill by collecting air, water, and soil samples from the affected area and analyzing them on - site using portable detection devices. The risk assessment team evaluates the potential health risks to the surrounding population, considering factors such as the toxicity of the spilled chemical, weather conditions, and the proximity of residential areas. The emergency response team is tasked with implementing immediate measures to contain the spill, such as building barriers, neutralizing the chemical, and evacuating the affected area if necessary. The communication team coordinates with local authorities, media, and the public to provide accurate and timely information about the incident.

The simulation is conducted using realistic props, equipment, and software, and is supervised by instructors who act as facilitators. During the simulation, students are faced with a series of dynamic challenges and unexpected situations, which require them to make quick decisions, adapt their strategies, and work effectively as a team. After the simulation, students participate in a debriefing session, where they reflect on their performance, discuss the lessons learned, and identify areas for improvement. This simulation - based training approach helps students develop the skills, knowledge, and confidence necessary to respond effectively to public health emergencies involving chemical hazards.

3.3 Optimization of the Evaluation System

3.3.1 Multidimensional Assessment Framework

To ensure a more comprehensive and accurate evaluation of students' learning outcomes, a multidimensional assessment framework has been developed. This

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framework goes beyond the traditional focus on technical skills and laboratory report writing and includes multiple dimensions of assessment that are relevant to public health practice.

The first dimension is technical proficiency, which assesses students' ability to perform chemical analysis techniques accurately and safely. This includes aspects such as proper instrument operation, accurate sample preparation, and reliable data collection. The second dimension is data analysis and interpretation, which evaluates students' ability to analyze experimental data using appropriate statistical methods, draw meaningful conclusions, and interpret the results from a public health perspective.

The third dimension is risk assessment, which measures students' ability to identify potential health risks associated with chemical exposures, collect relevant data, and use appropriate risk assessment models and tools to quantify these risks. The fourth dimension is the development of preventive measures and intervention strategies, which assesses students' ability to formulate evidence - based recommendations for preventing or mitigating health risks based on their experimental findings. Finally, the fifth dimension is communication skills, which evaluates students' ability to communicate their findings clearly and effectively to diverse audiences, including scientific peers, public health professionals, policymakers, and the general public.

For each dimension, clear assessment criteria and rubrics have been established to ensure consistency and objectivity in the evaluation process. This multidimensional assessment framework provides a more comprehensive and accurate picture of students' competencies, enabling educators to identify areas of strength and weakness and provide targeted feedback for improvement.

3.3.2 Multiple - Source Evaluation Model

To enhance the objectivity and comprehensiveness of the evaluation process, a multiple - source evaluation model has been implemented. This model combines the perspectives of teachers, peers, and industry experts to provide a more well - rounded assessment of students' performance.

Teacher assessment remains a crucial component of the evaluation system. Teachers, with their in - depth knowledge of the course content, learning objectives, and teaching methods, are able to provide detailed feedback on students' technical skills, understanding of theoretical concepts, and overall performance in the experiments. They evaluate students' laboratory work, including experimental design, data collection and analysis, and report writing, based on established assessment criteria and rubrics.

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Peer evaluation is also incorporated into the evaluation process to encourage collaborative learning and self - improvement. Students are given the opportunity to review and evaluate their classmates' work, providing constructive feedback on various aspects such as the quality of the experimental design, the clarity of the presentation, and the validity of the conclusions. This peer - to - peer interaction not only helps students learn from each other but also develops their critical thinking, communication, and teamwork skills.

In addition, industry experts from disease control centers, environmental monitoring agencies, food safety laboratories, and other relevant organizations are invited to participate in the evaluation process. These experts bring real - world experience, practical insights, and industry - specific knowledge to the assessment. They are able to evaluate students' work from the perspective of professional practice, providing valuable feedback on how well the students' projects meet the standards and requirements of the public health field. The integration of these multiple sources of evaluation ensures a more comprehensive, objective, and relevant assessment of students' learning outcomes, better preparing them for successful careers in public health.

4. Reform Results and Future Outlook

The reforms have increased students' engagement in public health - oriented experiments, with many projects receiving positive feedback from community health organizations. Moving forward, continuous collaboration with public health agencies, adoption of emerging detection technologies, and further refinement of teaching and assessment methods will be key to developing highly skilled preventive medicine professionals.

Reference

[1] Smith, J. (2019). Trends in preventive medicine education. Journal of Medical Education, 45(3), 210 - 218.

[2] Johnson, M. (2020). The role of laboratory courses in public health education. Health Education Quarterly, 37(2), 156 - 165.

[3] Brown, A., et al. (2021). Integrating chemical analysis in public health practice. Public Health Reviews, 42(1), 1 - 15.

[4] Davis, S. (2022). Modernizing experimental teaching in preventive medicine. Academic Medicine, 87(4), 501 - 508.

[5] Lee, C., et al. (2023). Advanced detection technologies in environmental monitoring. Environmental Science & Technology, 57(6), 1890 - 1902.

[6] Garcia - Rodriguez, L. (2024). Novel analytical methods for food safety

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assessment. Food Chemistry, 420, 135987.
[7] Wang, H., et al. (2021). Mass spectrometry applications in public health research. Journal of Proteomics, 239, 104056.
[8] Wilson, K., & Thompson, L. (2022). Gap analysis of chemistry education in public health programs. Journal of Public Health Education, 38(3), 199 - 207.
[9] Chen, X., et al. (2023). Updating laboratory curricula for modern public health needs. International Journal of Environmental Research and Public Health, 20(5), 4321.
[10] Jones, R., et al. (2020). Environmental pollutants and chronic diseases. Lancet Public Health, 5(7), e340 - e348.
[11] Taylor, M. (2021). The impact of emerging pollutants on public health. Environmental Health Perspectives, 129(6), 067001.
[12] White, A., et al. (2022). Competency - based training in public health risk assessment. Risk Analysis, 42(8), 1456 - 1468.
[13] Green, J., & Moore, S. (2023). A survey of teaching practices in public health chemistry courses. Journal of Chemical Education, 100(4), 1234 - 1242.
[14] Black, D., et al. (2020). Evidence - based public health: Principles and practice. Oxford University Press.
[15] Clark, S., et al. (2021). Advancing evidence - based decision - making in public health. American Journal of Public Health, 111(5), 865 - 872.
[16] Miller, J., et al. (2022). Experiential learning in public health education. Journal of Public Health Management & Practice, 28(3), 256 - 264.
[17] Anderson, L., et al. (2023). Simulation - based training for public health emergencies. Prehospital and Disaster Medicine, 38(2), 234 - 241.
[18] Young, K. (2020). The limitations of traditional teaching in public health. Health Professions Education, 6(2), 98 - 105.
[19] Kim, S. (2021). Shifting from teacher - centered to student - centered learning in public health education. Medical Education Online, 26(1), 1928928.

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