ISSN E 2959-3751
ISSN P 2959-3743

RICOS BIOLOGY JOURNAL

Vol. 3, no. 8
August, 2025

https://ricosbiology.net
https://ricospublisher.us
info@ricosbiology.net

Ricos Biology Journal, August, 2025, Vol. 3 (8) 1-32.
www.ricosbiology.net/Vol.3(8)/August-2025/1-32

RESEARCH ARTICLE
Open Access

Table of contents

Review Article

Recent Trends in Advanced Biosensors for Early Detection of Fungal Spoilage and Mycotoxication in Food of Animal Origin

Samah Eid[1], Elsayed S.E. Shabana[2], Amany N. Dapgh[3], Ahmed Shabaan[2], Ali Amer[3], Asmaa E. Gamal El-deen[3], Wagdy S.B.Youssef[3], Ashraf S. Hakim[4] and Hussien A. Abouelhag[4]

[1]Reference Laboratory for Veterinary Quality Control on Poultry Production, Animal Health Research Institute, Agriculture Research Center (ARC), Giza, Egypt.

[2]Department of Food Hygiene, Animal Health Research Institute, Agriculture Research Center (ARC), Dokki, Giza, Egypt.

[3]Bacteriology department, Animal Health Research Institute, Agriculture Research Center (ARC), Dokki, Giza, Egypt.

[4]Department of Microbiology and Immunology, National Research Centre, 33 Bohouth St., Dokki, Cairo, Egypt.

Corresponding author: Amany N. Dapgh **E-mail:** amany.nabil.dapgh@gmail.com

Received: 29-07-2025, **Accepted:** 16-08-2025. **Published online:** 23-08-2025
DOI: https://doi.org/10.33687/ricosbiol.03.08.68

Abstract

The public health concern induced by mycotoxins contamination has globally retained a prominent deal of interest. Mycotoxins are secondarily synthetized and can accumulate in host organs so institute adverse effects on humans and livestock, resulting in grave health threats and often produced by certain filamentous fungi broadly found in foodstuffs. Enhancing early trace recognition and control from the root is a more coveted approach than the disposal way to assert food safety. Biosensors are ready to interference from various components in intricate food matrices when recognizing trace mycotoxins. This article focuses on advanced approaches especially incorporation of biosensors for detection of mycotoxins in food matrices of animal origin as well as progressing of sensing detection for food safety assurance.

Key words: Mycotoxins, milk, meat, food safety, biosensors.

Introduction

Mycotoxins are toxic secondary metabolites formed as secondary metabolites by different filamentous fungal species and produced under particular circumstances (Pandey et al., 2023). According to the previous reports, there are more than 500 mycotoxins that have been recognized as toxigenic and harmful to plant, animal, and human health and so far, could be differentiated to groups following their own toxic impacts. The most prevalent

established types involve Aflatoxins (AFTs), Citrinin (CT), Fumonisins (FUMs), Ochratoxins (OTs), Patulin (PAT), Trichothecenes (TCTs), and Zearalenone (ZEN) (Haque *et al*., 2020).

Mycotoxins compress a set of structurally assorted low molecular weight chemical compounds, commonly less than 1000 Da produced when temperature within the range of 25 ± 5 °C. Additionally, water activity is also a substantial factor affecting mycotoxin synthesis, which informs the quantity of water attainable for microbial and chemical paths within a substance like food (Janik *et al*., 2020).

Mycotoxins are sorely poisonous and their consumption may result in acute or chronic health issues. Mycotoxicosis, has accompanied with signs may vary relying on the type of mycotoxin and may comprise the persuading: cytotoxicity, hepatotoxicity, nephrotoxicity, neurotoxicity, teratogenicity, and carcinogenicity (Pandey *et al*., 2023).

Since the premier discovery of mycotoxins, many analytical techniques have been scouted and employed for estimating their existence in food and feed. Chromatographic methods have often been utilized, due to their versatility, these comprise thin-layer chromatography (TLC) and high-performance liquid chromatography (HPLC), in coupling with a scope of detectors such as diode array, fluorescence and UV, as well as, gas chromatography–tandem mass spectrometry (GC-MS/MS) and liquid chromatography–tandem mass spectrometry (LC-MS/MS). Moreover, it is also noting the worthy role of antibody-based immunoassays in mycotoxin recognition (Yang *et al*., 2020).

Essentially, a biosensor is an advanced analytical tool that combines biological sensing components, like antibodies, enzymes, organelles even whole cells or tissues with a transducer that known as bioreceptor. The bioreceptor segment which also termed as 'the detector element' has a selective site able to define the target and converts the biological interaction into a detectable signal, such as an electrical, optical, or thermal output. This measurable signal is directly proportional to the concentration of the specific analyte or group of analytes of concern. The type of transducer used relies on the biosensor's specific outlay while the type of biosensor is defined by transducer mechanism (Gaudin, 2017).

Methodology

1. *Running Approaches in Mycotoxins Recognition*

1.1. Sampling

Following to present knowledge, the readiness of a specimen for identification requires the achievement of procedures involving sampling, grinding, mixing, extraction, and purification. The contamination of natural, solid products with mycotoxins is non-homogeneous and may display random allocation, possibly resulting in false -ve data and the failure to recognize presenting threats when sampling from improper areas is carried out (Zhang *et al*., 2018).

1.2. Sample Readiness: Extraction and Purification

After sampling, the specimen should be ground and mixed to permit and speed up the chemical reaction processes. Relied on the previous literature, the homogenized particles' final size should be 500 µm approximately (Nakhjavan *et al*., 2020). There are abundant various methods for extracting mycotoxin, and the proper choice of the pretreatment approach is necessary because of the different consistencies of food products. Relied on the traditional methods, the most prevalent selected are Solid–Liquid Extraction (SLE), Solid-Phase Extraction (SPE), and QuEChERS.

SLE is one of the most prevalent tehniques used to extract mycotoxins from various foodstuffs. SLE is easy to conduct and does not necessitate large financial budgets and any particular instruments. However, to obtain precise and perfect results, the solvent must be carefully chosen (Bian *et al*., 2023). ii. Solid-Phase Extraction (SPE) is an efficient technique used to extract mycotoxins. The liquid sample that comprises the analytes of interest is passed via the unique cartridge that includes high-affinity adsorbent particles. SPE is superior to other conventional methods, as it minimizes solvent usage, efficient concentration, and promoted recovery rates (Badawy *et al*., 2022). iii. QuEChERS, this doubled technique name is interestingly coming from the persuading terms: Quick, Easy, Cheap, Effective, Rugged, and Safe (Pereira *et al*., 2015). Like in the formerly described technique, the key of the good optimization of QuEChERS is a good choice of sorbents (Badawy *et al*., 2022).

2. *Techniques Used for Mycotoxin Recognition*

2.1. Thin-Layer Chromatography (TLC) is a type of liquid chromatography that was broadly employed between in the last twenty years in the past century and still in use today because of its low analysis cost. TLC employs a stationary phase typically formed of silica, cellulose, or alumina, pasted to an inert material such as plastic or glass that retains the analyte in place through separation. Meanwhile, the mobile phase, often including acetonitrile, methanol, and water mixtures, transmits the specimen across the stationary phase (Meyers and Meyers, 2008). The visualization of TLC can be classified into three prime categories: destructive (chemical compounds, ninhydrin, bromocresol green, and p-methoxy benzaldehyde), semi-destructive (iodine staining), and non-destructive (UV staining) (Ventura *et al*., 2005).

2.2. Liquid chromatography (LC) is one of sensitive, more specific, and automated techniques developed to overcome the disadvantages of TLC. LC permits the simultaneous recognition of many mycotoxins, however of their biological activity and chemical composition. LC is more efficient in identifying mycotoxins but it necessitates remarkably greater financial budget, involving the purchase of convenient equipment (Yang *et al*., 2020).

2.3. High-performance liquid chromatography (HPLC) is a gold-standard technique in the assessment of mycotoxin contamination in different foodstuffs. The guidelines for their detection greatly follow similar techniques, using fluorescence detectors, UV–visible or even mass spectrometry to enhance the sensitivity and effectiveness (Turner *et al*., 2009).

2.4. Gas Chromatography (GC) is a chromatography type of which the mobile phase is gas. GC is less used for the recognition and quantification of mycotoxins in food specimens so a commercial protocol for GC not obtained, especially with the presence of faster and cheaper methods like HPLC (Rodríguez-Carrasco *et al*., 2014).

2.5. Enzyme-linked immunosorbent assay (ELISA) is considered one of the most prevalent employed antibody-based immunoassays for mycotoxin determination. ELISA exposes the simple, rapid, reliable, and simultaneous analysis of numerous specimens. ELISA kits are usually relied on a competitive assay format and characterized by its high specificity, portability and fast execution time. ELISA kits are limited for single use, which may elevate the cost of conducting a screening assay of abundant mycotoxins (Maggira *et al*., 2022).

2.6. Lateral flow immunoassay (LFA) is a low-cost, simple, paper-based antibody-based immunoassay test for the rapid detection and quantification of different analytes as mycotoxins, aflatoxin M1 in milk (Singh *et al*., 2022).

3. *Mycotoxin Detection Techniques*

3.1. Fluorescence sensors which detect target analytes depending on the absorption and subsequent re-emission of photons by excited atoms or molecules either via their inherent fluorescence or through conjugation with a fluorophore (Lu *et al*., 2016). Fluorescent sensors are featured by their sensitivity, affordability, and rapid response time so offer the accurate identification and quantitative measurement of food contaminants as well as toxin recognition in milk (Naz *et al*., 2025).

3.2. Electrochemiluminescence, (ECL), is a type of luminescence sensor output during electrochemical reactions in solutions, the prime advantage of this technique is that there is no necessity for an excitation light source. ECL reactions are precisely controlled by electrical potential and outright in processes. These features make ECL technology an excellent tool for recognizing tiny amounts of toxins in food and the environment, as well as for diagnosing illnesses (Lv *et al*., 2023). Relying on the kinds of sensing components utilized, ECL biosensors can be classified into 3 groups, based on antibodies, aptamers, as well as molecular imprinting polymers (MIPs).

3.2.1. Immunosensors, employing antibodies as detection elements, display heightened specificity and sensitivity arisen from the unique merits of the binding between antigens and antibodies carried on nanoparticles (Li *et al*., 2021). These nanoparticles gave anchoring sites for immobilizing another antibody and served as efficient carriers (Lv *et al*., 2023). Immunosensors were applied for the precise detection of Aflatoxin M1 (AFM1) in milk and dairy products (Angelopoulou *et al*., 2023) as well as T-2 toxin in swine meat (Wang *et al*., 2018). Otherwise, there are existed challenges and limitations to be addressed in the utilization of immunosensors. Antibody bioactivity is sensitive to environmental circumstances, and this led to notable possibility of cross-reactions between antibodies and other biomolecules. This concern results in inaccurate data, involving both false positives and

false negatives during real specimen analysis. Therefore, it is fundamentally, that the accuracy and reliability of recognition are further modulated and developed in future studies, contribute to reliable and precise mycotoxin detection (Szelenberger *et al*., 2024).

3.2.2. Aptamer-Based Biosensor are short, single-stranded RNA or DNA (ssRNA or ssDNA) molecules that can selectively bind to a particular target, involving proteins, toxins, small molecules, and even live cells. In converse to antibodies, aptamers are not susceptible to temperature and are chemically stable, therefore, it is a promising ECL approach particularly for its prospect of coupling nanoparticles featuring unique physical and chemical merits to the terminal of nucleic acids (Jia *et al*., 2022). Updated various DNA hybridization techniques have been utilized in mycotoxin detection, Aflatoxin B1, Aflatoxin M1in milk and fumonisin B_1 in meat (Ahmadi *et al*., 2022, Ramezani *et al*., 2022 and Sun *et al*., 2023).

3.2.3. Molecular Imprinted polymers (MIPs) have acquired fundamental attention for their peculiar advantages, comprising exceptional selectivity, rapidity, reusability, and simplicity. Molecular imprint plays a pivotal role in these detection processes by achieving specific cavities that mimic the structure and shape of target molecules. These unique properties have resulted in the employment of MIP approaches for the efficient label-free recognition of mycotoxins, aflatoxins (Díaz-Bao *et al*., 2016) and zearalenone (Yugender Goud *et al*., 2019). In spite of some drawbacks, average sensitivity, a restricted ability to detect macromolecular targets, and complex preparation steps, MIPs have continued progresses and enhanced the abilities to meet analytical requirements across industries (Szelenberger *et al*., 2024).

4. *Incorporated Biosensor Implementations in Food Safety Management*

Food safety links to the assertion that food, when readiness and consumed as proposed, does not induce harm upon the consumer (Sorbo *et al*., 2022). Legislation intending food safety in developing countries is broadly not established, constituting a concern of health protection. The overall principle is to utilize an incorporated approach, involving all sides of the food chain, from farm to fork. Attachment to food safety requirements the systematic management of food hygiene and standards, asserting that the food products supplied are considered safe for consumption so it is necessary to establish a scientific basis for risk management (Lizakowski, 2019).

Naturally sourced food products often load microbiological risks. Even with significant progress in food safety, microorganisms remain the biggest threat to what we consume. To address this, microbiological criteria provide guidelines for the acceptability of food products and their production processes (Sosnowski and Osek, 2021). Preventive measures are substantial for food safety as Good Hygiene and Manufacturing Practices (GHP, GMP), Hazard Analysis Critical Control Points (HACCP) principles and Food Contact Material (FCM) Migration Testing (Eid *et al*., 2025).

Animal products such as meat, milk, eggs, or offal can be contaminated via the animals' diet. This highlights the need for a comprehensive approach to monitoring and controlling the existence of mycotoxins (El-Sayed *et al*., 2020). The use of biosensors in meat processing plants, encompassing slaughterhouses and dairies, can play a pivotal role in early recognition and prevention. By monitoring the existence of mycotoxins, these biosensors can aid and assert that meat and dairy products couple stringent safety standards prior to reaching consumers.

Conclusion

Biosensors are constantly improving and being integrated into food safety systems, showing that this is a rapidly changing field with huge potential to make our food supply safer and better. As technology, connectivity, and teamwork across different disciplines advance, we'll see even more uses for biosensors in keeping our food safe.

References

Ahmadi SF, Hojjatoleslamy M, Kiani H and Molavi H. (2022) Monitoring of Aflatoxin M1 in milk using a novel electrochemicalaptasensorbased on reduced graphene oxide and gold nanoparticles. Food Chem. 30,373(Pt A):131321.

Angelopoulou M, Kourti D, Misiakos K, Economou A, Petrou Pand Kakabakos S. (2023). Mach-Zehnder Interferometric Immunosensor for Detection of Aflatoxin M1 in Milk, Chocolate Milk, and Yogurt. Biosensors (Basel). 30,13(6),592.

Badawy M.E.I., El-Nouby M.A.M., Kimani P.K., Lim L.W. and Rabea E.I. (2022). A review of the modern principles and applications of solid-phase extraction techniques in chromatographic analysis. Anal. Sci.,38,1457–1487.

Bian Y., Zhang Y., Zhou Y., Wei B. and Feng X. (2023). Recent Insights into Sample Pretreatment Methods for Mycotoxins in Different Food Matrices: A Critical Review on Novel Materials. Toxins, 15,215.

Díaz-Bao M, Regal P, Barreiro R, Fente CA. and Cepeda A. (2016). A facile method for the fabrication of magnetic molecularly imprinted stir-bars: A practical example with aflatoxins in baby foods. J Chromatogr A., 1471,51-59.

Eid S., Gehad F.A. Fath Elbab , Amany N. Dapgh, Hakim A. S., Wagdy S.B. Youssef and Hussien A. Abouelhag. (2025). Food Contact Material (FCM) Migration Testing: Novel Assay for Ensuring Food Safety. Ricos Biology Journal, Vol. 3 (7) 12-16.

El-Sayed R., Jebur A., Kang W., El-Esawi M. and El-Demerdash F. (2020). An overview on the major mycotoxins in food products: Characteristics, toxicity, and analysis. J. Future Foods, 2,91–102.

Gaudin V. (2017). Advances in biosensor development for the screening of antibiotic residues in food products of animal origin—A comprehensive review. Biosens. Bioelectron, 90,363–377.

Yang Y., Li G., Wu D., Liu J., Li X., Luo P., Hu N., Wang H. and Wu Y. (2020). Recent advances on toxicity and determination methods of mycotoxins in foodstuffs. Trends Food Sci. Technol, 96,233–252.

Haque M.A., Wang Y., Shen Z., Li X., Saleemi M.K. and He C. (2020). Mycotoxin contamination and control strategy in human, domestic animal and poultry: A review. Microb. Pathog., 142,104095.

Janik E., Niemcewicz M., Ceremuga M., Stela M., Saluk-Bijak J., Siadkowski A. and Bijak M. (2020). Molecular Aspects of Mycotoxins—A Serious Problem for Human Health. Int. J. Mol. Sci., 21,8187.

Jia M., Jia B., Liao X., Shi L., Zhang Z., Liu M., Zhou L., Li D. and Kong W. (2022). A CdSe@CdS quantum dots based electrochemiluminescence aptasensor for sensitive detection of ochratoxin A. Chemosphere, 287,131994.

Li M., Yue Q., Fang J., Wang C., Cao W. and Wei Q. (2022). Au modified spindle-shaped cerium phosphate as an efficient co-reaction accelerator to amplify electrochemiluminescence signal of carbon quantum dots for ultrasensitive analysis of aflatoxin B1. Electrochim. Acta., 407,139912.

Lizakowski P K.A. (2019). Legal regulations and administration of food safety. World Sci. News., 122,133–144.

Lu S., Li G., Lv Z., Qiu N., Kong W., Gong P., Chen G., Xia L., Guo X., You J. and *et al.* (2016). Facile and ultrasensitive fluorescence sensor platform for tumor invasive biomarker beta-glucuronidase detection and inhibitor evaluation with carbon quantum dots based on inner-filter effect. Biosens. Bioelectron, 85,358–362.

Lv X., Tan F., Miao T., Cui B., Zhang J., Fang Y. and Shen Y. (2023). In situ generated PtNPs to enhance electrochemiluminescence of multifunctional nanoreactor COP T(4)VTP(6) for AFB(1) detection. Food Chem., 399,134002.

Maggira M, Sakaridis I, Ioannidou M and Samouris G. (2022). Comparative Evaluation of Three Commercial Elisa Kits Used for the Detection of Aflatoxins B1, B2, G1, and G2 in Feedstuffs and Comparison with an HPLC Method. Vet Sci., 9(3),104.

Meyers C.L.F. and Meyers D.J. (2008). Thin-Layer Chromatography. Curr. Protoc. Nucleic Acid. Chem., 34, A.3D.1–A.3D.13.

Nakhjavan B., Ahmed N.S. and Khosravifard M. (2020). Development of an improved method of sample extraction and quantitation of multi-mycotoxin in feed by LC-MS/MS. Toxins, 12,462.

Naz I, Alanazi SJF, Hayat A and Jubeen F. (2025). Covalent organic framework-based aptananozyme (COF@NH_2 apt-AFM_1): A novel platform for colorimetric and fluorescent aptasensing of AFM_1 in milk. Food Chem., 484,144478.

Pandey A.K., Samota M.K., Kumar A., Silva A.S. and Dubey N.K. (2023). Fungal mycotoxins in food commodities: Present status and future concerns. Front. Sustain. Food Syst., 7,1162595.

Pereira V., Fernandes J. and Cunha S. (2015). Comparative assessment of three cleanup procedures after QuEChERS extraction for determination of trichothecenes (type A and type B) in processed cereal-based baby foods by GC–MS. Food Chem., 182,143–149.

Ramezani M, Jalalian SH, Taghdisi SM, Abnous K and Alibolandi M. (2022). Optical and Electrochemical Aptasensors for Sensitive Detection of Aflatoxin B_1 and Aflatoxin M_1 in Blood Serum, Grape Juice, and Milk Samples. Methods Mol Biol., 2393,417-436.

Rodríguez-Carrasco Y., Moltó J.C., Berrada H. and Mañes J. (2014). A survey of trichothecenes, zearalenone and patulin in milled grain-based products using GC–MS/MS. Food Chem.,146,212–219.

Singh H, Singh S, Bhardwaj SK, Kaur G, Khatri M, Deep A and Bhardwaj N. (2022). Development of carbon quantum dot-based lateral flow immunoassay for sensitive detection of aflatoxin M1 in milk. Food Chem., 1 393,133374.

Sorbo A., Pucci E., Nobili C., Taglieri I., Passeri D. and Zoani C. (2022). Food Safety Assessment: Overview of Metrological Issues and Regulatory Aspects in the European Union. Separations, 9,53.

Sosnowski M. and Osek J. (2021). Microbiological Safety of Food of Animal Origin from Organic Farms. J. Vet. Res., 65,87–92.

Sun Y, Lv Y, Zhang Y and Wang Z. (2023). A stimuli-responsive colorimetric aptasensor based on the DNA hydrogel-coated MOF for fumonisin B_1 determination in food samples. Food Chem., 403,134242.

Szelenberger R, Cichoń N, Zajaczkowski W and Bijak M. (2024). Application of Biosensors for the Detection of Mycotoxins for the Improvement of Food Safety. Toxins (Basel), 27 16(6),249.

Turner N.W., Subrahmanyam S. and Piletsky S.A. (2009). Analytical methods for determination of mycotoxins: A review. Anal. Chim. Acta, 632,168–180.

Ventura M, Anaya I, Broto-Puig F, Agut M and Comellas L. (2005). Two-dimensional thin-layer chromatographic method for the analysis of ochratoxin A in green coffee. J Food Prot., 68(9),1920-2.

Wang Y, Zhang L, Peng D, Xie S, Chen D, Pan Y, Tao Y and Yuan Z. (2018). Construction of Electrochemical Immunosensor Based on Gold-Nanoparticles/Carbon Nanotubes/Chitosan for Sensitive Determination of T-2 Toxin in Feed and Swine Meat. Int J Mol Sci., 19(12),3895.

Yugender Goud K., Sunil Kumar V., Hayat A., Vengatajalabathy Gobi K., Song H., Kim K.-H. and Marty J.L. (2019). A highly sensitive electrochemical immunosensor for zearalenone using screen-printed disposable electrodes. J. Electroanal. Chem., 832,336–342.

Zhang L., Dou X.-W., Zhang C., Logrieco A.F. and Yang M.-H. (2018). A review of current methods for analysis of mycotoxins in herbal medicines. Toxins, 10,65.

Review Article

Comprehensive Review on Venereal Diseases Transmission: Transmission Routes, Diagnosis, Treatment, Prognosis, Future Medications, and Recommendations

Abouelhag H. A.

Department of Microbiology and Immunology, National Research Centre, Dokki, Giza, Egypt, 12622.

Corresponding author: Abouelhag H. A. (Email: drabouelhag5@gmail.com)

Received: 29-07-2025, **Accepted:** 16-08-2025. **Published online:** 23-08-2025

DOI: https://doi.org/10.33687/ricosbiol.03.08.70

Abstract

Sexually Transmitted Infections (STIs) are among the most common communicableconditions worldwide, affecting the health and lives of people globally. The World Health Organization estimates that over one million new STI infections occur daily among adults aged 15-49. This comprehensive review aims to provide an in-depthanalysis of venereal disease transmission routes, modern diagnostic methods, available treatment options, future prognosis, emerging medications, and preventive recommendations. This review covers major diseases such as Chlamydia, Gonorrhea, Syphilis, Human Papillomavirus (HPV), Human Immunodeficiency Virus (HIV), Genital Herpes, and other sexually transmitted infections. It also discusses recent advancements in molecular diagnostics, antimicrobial resistance, new preventive strategies, vaccinations, and future therapies. The findings emphasize the importance of early diagnosis, prompt treatment, and partner management in controlling the spread of these diseases. Recent data indicate that over 2.4 million cases of Syphilis, Gonorrhea, and Chlamydia were diagnosed and reported in the United States in 2023,underscoring the continuous need for comprehensive prevention and treatment strategies.

Keywords: Sexually Transmitted Infections, Venereal Diseases, Transmission Routes,Diagnosis, Treatment, Prevention, Antimicrobial Resistance

Transmission Routes

Sexually Transmitted Infections (STIs) are primarily transmitted from person to person through unprotected sexual contact, which includes vaginal, anal, and oral intercourse (CDC, 2021). However, some STIs can be transmitted through non-sexual means, making anunderstanding of transmission mechanisms crucial for prevention and control.Transmission routes can be categorized into several main types:

1. Direct Sexual Contact

Direct sexual contact is the most common mode of transmission for most STIs. Thisoccurs when mucous membranes or bodily fluids (such as semen, vaginal secretions,

and blood) from an infected person come into contact with the mucous membranes or open wounds of an uninfected person. Diseases transmitted this way include:

Chlamydia and Gonorrhea: These bacteria are primarily transmitted through vaginal, anal, and oral sexual contact. They can affect the genitals, rectum, andthroat (CDC, 2021).

Syphilis: Syphilis is transmitted through direct contact with syphilitic sores(chancres) that appear on the genitals, anus, rectum, lips, or mouth (CDC, 2021).

Herpes Simplex Virus (HSV): Herpes virus is transmitted through direct contactwith herpes sores or the fluids they exude, even in the absence of visible sores (CDC, 2021).

Human Papillomavirus (HPV): HPV is transmitted through direct skin-to-skincontact, usually during sexual activity. It can cause genital warts and certain types of cancer (CDC, 2021).

Human Immunodeficiency Virus (HIV): HIV is primarily transmitted through unprotected sexual contact (vaginal or anal) where blood, semen, or vaginal secretions from an infected person enter the bloodstream of an uninfected person. It can also be transmitted through oral sexual contact, although this isless common (CDC, 2021).

2. Mother-to-Child Transmission (Vertical Transmission)

Some STIs can be transmitted from an infected mother to her child during pregnancy, childbirth, or breastfeeding. This type of transmission can cause serious health complications for the infant, including birth defects, infections, and even death (CDC, 2021). Diseases transmitted vertically include:

Congenital Syphilis: Syphilis bacteria can be transmitted from an infected mother to the fetus during pregnancy, leading to congenital syphilis, which cancause severe health problems for the infant (CDC, 2021).

Human Immunodeficiency Virus (HIV): HIV can be transmitted from mother tochild during pregnancy, childbirth, or breastfeeding. However, the risk of transmission can be significantly reduced through antiretroviral therapy for the mother during pregnancy and childbirth, and by avoiding breastfeeding (CDC, 2021).

Chlamydia and Gonorrhea: These bacteria can be transmitted to the infantduring birth, causing eye or lung infections (CDC, 2021).

Genital Herpes: If the mother has active herpes sores during childbirth, the viruscan be transmitted to the infant, causing a serious, potentially life-threatening infection (CDC, 2021).

3. Blood Contact

Some STIs can be transmitted through contact with contaminated blood. This typically occurs through:

Sharing Needles: Sharing needles or syringes contaminated with blood is acommon route of transmission for HIV and viral hepatitis (B and C) among injecting drug users (CDC, 2021).

Blood Transfusion and Organ Transplantation: Although now very rare indeveloped countries due to rigorous screening of blood and organs, it still represents a potential risk (CDC, 2021).

Needlestick Injuries: Healthcare workers can be at risk of bloodborne infectionsthrough accidental needlestick injuries (CDC, 2021).

4. Other (Less Common) Transmission Routes

Direct Non-Sexual Contact: In rare cases, some STIs can be transmitted throughclose skin-to-skin or mucous membrane contact, even without full sexual intercourse. For example, oral herpes can be transmitted through kissing (CDC, 2021).

Contaminated Instruments: Although rare, improperly sterilized medical orsurgical instruments can be a vehicle for the transmission of some STIs (CDC, 2021).

Understanding the various transmission routes highlights the importance of safe sexual practices, regular screening, and preventive interventions such as vaccinations(e.g., HPV vaccine) in curbing the spread of STIs (CDC, 2021).

Diagnosis

Early and accurate diagnosis of Sexually Transmitted Infections (STIs) is crucial for preventing serious health complications and curbing the spread of infection. Diagnostic methods vary depending on the type of infection and include a wide range of laboratory tests and clinical examinations (CDC, 2021).

1. Diseases Characterized by Genital, Anal, or Perianal Ulcers

These diseases include Syphilis, Genital Herpes, Lymphogranuloma Venereum (LGV),and Granuloma Inguinale (Donovanosis). Diagnosis relies on clinical observation and laboratory tests:

Syphilis: Syphilis is definitively diagnosed through darkfield microscopy or molecular tests (PCR) to detect *Treponema pallidum* directly from lesion exudate or tissue. Presumptive diagnosis relies on two serologic tests: a nontreponemal test (VDRL or RPR) and a treponemal test (TP-PA, EIAs, CIAs, immunoblots, or rapid treponemal assays). Nontreponemal tests can yield false-positive results and are used to monitor treatment response, while treponemal tests remain positive for life even after successful treatment (CDC, 2021).

Lymphogranuloma Venereum (LGV): Definitive diagnosis of LGV requires LGV-specific molecular testing (e.g., PCR-based genotyping), which is not widely available. Diagnosis is typically based on clinical suspicion, epidemiological

information, and a *Chlamydia trachomatis* NAAT at the symptomatic anatomicalsite, along with the exclusion of other etiologies (CDC, 2021).

2. Diseases Characterized by Urethritis and Cervicitis

These include Chlamydia and Gonorrhea, which are often asymptomatic, especially inwomen:

Chlamydia and Gonorrhea: Nucleic Acid Amplification Tests (NAATs) are the preferred method for diagnosing Chlamydia and Gonorrhea due to their high sensitivity and specificity. Urine samples or swabs from various anatomical sites(cervix, vagina, urethra, rectum, pharynx) can be used (CDC, 2021).

Mycoplasma genitalium: NAATs are the recommended diagnostic tests for *Mycoplasma genitalium*. Resistance testing is crucial for guiding treatment due to increasing antimicrobial resistance (CDC, 2021).

3. Diseases Characterized by Vulvovaginal Itching, Burning, Irritation, Odor, or Discharge

These include Bacterial Vaginosis (BV), Vulvovaginal Candidiasis (VVC), and Trichomoniasis:

Bacterial Vaginosis (BV): Diagnosis relies on microscopic examination of wet mount showing clue cells, an elevated pH (>4.5), and a KOH test yielding an amine odor. Clinical laboratory tests can also be used (CDC, 2021).

Vulvovaginal Candidiasis (VVC): Diagnosis relies on clinical indicators such as vulvar itching and pain, and microscopic examination showing budding yeasts orpseudohyphae. VVC is associated with a normal vaginal pH (<4.5). Yeast culture isthe gold standard for diagnosis (CDC, 2021).

4. Other Diseases

Human Immunodeficiency Virus (HIV): HIV infection is diagnosed by HIV 1/2 Ag/Ab combination immunoassays. The CDC recommends that HIV testing begin with a laboratory-based HIV-1/HIV-2 Ag/Ab combination assay, followed by a laboratory-based assay with a supplemental HIV-1/HIV-2 antibody differentiation assay if repeatedly reactive (CDC, 2021).

Viral Hepatitis (B and C): Viral Hepatitis (B and C) is diagnosed through bloodtests that detect antigens, antibodies, and viral nucleic acid (CDC, 2021).

Human Papillomavirus (HPV): HPV is typically diagnosed through Pap tests todetect cellular changes, and HPV DNA tests to detect high-risk viral types (CDC, 2021).

Regular screening, especially for at-risk individuals, is vital for early diagnosis and effective intervention. Accurate diagnosis also guides appropriate treatment and reduces the risk of transmission (CDC, 2021).

Treatment

The treatment of Sexually Transmitted Infections (STIs) depends on the type of infection, whether bacterial, viral, fungal, or parasitic. The goal of treatment is to eliminate the pathogen, alleviate symptoms, prevent complications, and stop the

transmission of infection to others. It is essential to adhere to the full and recommended doses of medications, even if symptoms disappear, to ensure completecure and prevent the development of antimicrobial resistance (CDC, 2021).

1. Curable Bacterial Infections

Bacterial infections are treated with antibiotics and are curable if diagnosed and treated early:

Syphilis: Penicillin G is the preferred drug for all stages of syphilis, administered parenterally. The dosage and duration of treatment depend on the stage of the disease and clinical manifestations. Patients should be informed about the potential Jarisch-Herxheimer reaction, an acute febrile reaction that can occur within 24 hours of syphilis therapy (CDC, 2021).

Chlamydia: Doxycycline 100 mg orally twice daily for 7 days is the recommended treatment. Azithromycin 1 gram orally as a single dose can be used as an alternative, especially during pregnancy (CDC, 2021).

Gonorrhea: Gonorrhea treatment has become complicated due to the ability of *Neisseria gonorrhoeae* to develop resistance to available antibiotics. The 2021 CDC guidelines recommend ceftriaxone 500 mg intramuscularly as a single dose. Dual therapy with azithromycin or doxycycline, previously recommended, is no longer advised due to concerns about azithromycin resistance (CDC, 2021).

Mycoplasma genitalium: Resistance-guided therapy is emphasized due to increasing antimicrobial resistance. A two-stage approach is recommended: an initial dose of doxycycline to reduce the microbial load, followed by either high-dose azithromycin (for macrolide-sensitive infections) or moxifloxacin (for macrolide-resistant infections). If resistance testing is not available, doxycyclinefollowed by moxifloxacin is recommended (CDC, 2021).

Bacterial Vaginosis (BV): Metronidazole 500 mg orally twice daily for 7 days, or metronidazole gel 0.75% intravaginally, or clindamycin cream 2% intravaginally are recommended. Women should be advised to abstain from sexual activity orconsistently use condoms during the treatment period (CDC, 2021).

Pelvic Inflammatory Disease (PID): Empiric treatment for PID should be initiated in sexually active young women and other women at risk for STIs if they experience pelvic or lower abdominal pain. Recommended regimens include a combination of intravenous or intramuscular antibiotics, such as ceftriaxone with doxycycline and metronidazole (CDC, 2021).

Epididymitis: Treatment depends on the likely cause. If caused by Chlamydia or Gonorrhea, ceftriaxone 500 mg IM as a single dose plus doxycycline 100 mg orallytwice daily for 10 days is recommended. If caused by enteric organisms, levofloxacin is recommended (CDC, 2021).

2. Chronic Viral Infections

There is no cure for most viral STIs, but symptoms can be managed and recurrence

reduced:

Human Immunodeficiency Virus (HIV): Antiretroviral therapy (ART) should be initiated as soon as possible for all persons with HIV infection, regardless of CD4+T-cell count. ART significantly reduces transmission, improves laboratory markers, decreases acute disease severity, lowers viral setpoint, reduces viral reservoir size, decreases viral mutation rate, and preserves immune function (CDC, 2021).

Genital Herpes: Antiviral medications such as acyclovir, valacyclovir, and famciclovir are used to manage herpes outbreaks and reduce recurrence. Thesedrugs do not eliminate the virus from the body but help control symptoms (CDC, 2021).

Human Papillomavirus (HPV): There is no cure for HPV itself, but clinical manifestations such as genital warts can be treated. Treatment options include surgical removal of warts, cryotherapy, laser therapy, or topical medications. HPV

vaccines are an effective means of preventing infection and associated cancers(CDC, 2021).

Viral Hepatitis (B and C): Effective treatments are available for Hepatitis C thatcan lead to complete cure in most cases. For chronic Hepatitis B, antiviral medications can control the virus and prevent liver damage (CDC, 2021).

3. Fungal and Parasitic Infections

Vulvovaginal Candidiasis (VVC): VVC is treated with short-course topicalformulations (single dose or 1-3 day regimens) or a single oral dose of fluconazole. These treatments are effective in relieving symptoms and eradicating the infection (CDC, 2021).

Trichomoniasis: Trichomoniasis is treated with oral metronidazole or tinidazole.It is important to treat sexual partners simultaneously to prevent reinfection (CDC, 2021).

Adherence to treatment, partner management, and regular follow-up are crucial for successful treatment and reducing the spread of STIs (CDC, 2021).

Prognosis

The prognosis of Sexually Transmitted Infections (STIs) largely depends on the type of infection, the stage of diagnosis, adherence to treatment, and the presence of any complications. While many STIs are completely curable if diagnosed and treated early, others can cause chronic or even life-threatening health problems if left untreated (CDC, 2021).

1. Curable Bacterial Infections

Chlamydia and Gonorrhea: If diagnosed and treated early with appropriate antibiotics, the prognosis is excellent, and complete recovery usually occurs without complications. However, if left untreated, they can lead to serious complications such as Pelvic Inflammatory Disease (PID) in women, which cancause infertility, ectopic pregnancy, and chronic pelvic pain. In men, they can cause epididymitis, which may affect fertility (CDC,

2021).

Syphilis: Syphilis can be effectively treated with penicillin, especially in the earlystages (primary, secondary, and early latent syphilis). The prognosis is very goodwith proper treatment. However, if the disease progresses to late stages (late latent syphilis, tertiary syphilis, neurosyphilis), it can cause irreversible damageto vital organs such as the heart, brain, and nervous system, leading to chronichealth problems, disability, and in some cases, death (CDC, 2021).

Bacterial Vaginosis (BV) and Trichomoniasis: These infections are curable withantibiotics. The prognosis is good with treatment. However, they can increase the risk of acquiring other STIs and cause pregnancy complications if left untreated (CDC, 2021).

2. Chronic Viral Infections

Human Immunodeficiency Virus (HIV): There is currently no cure for HIV, butwith effective Antiretroviral Therapy (ART), people living with HIV can lead longand healthy lives. ART reduces the viral load to undetectable levels, preventingthe progression to AIDS and significantly reducing the risk of HIV transmission. However, treatment requires lifelong adherence (CDC, 2021).

Genital Herpes: There is no cure for genital herpes, and the virus remains in thebody for life. However, antiviral medications can reduce the frequency and severity of outbreaks. The prognosis is good in terms of symptom management, but the infection can cause psychological and social distress (CDC, 2021).

Human Papillomavirus (HPV): Most HPV infections clear on their own without intervention. However, some high-risk HPV types can lead to the development ofcervical, anal, oral, and throat cancers, among others. The prognosis depends onearly detection and treatment of cellular changes. HPV vaccines offer excellent protection against infection and associated cancers (CDC, 2021).

Viral Hepatitis B and C: Hepatitis B can become chronic and lead to cirrhosis and liver cancer. Antiviral treatments are available that can control the virus. Hepatitis C, in contrast, can be effectively cured in most cases using direct-actingantiviral medications, leading to complete recovery and preventing long-term complications (CDC, 2021).

3. Long-Term Complications

If left untreated, STIs can lead to a wide range of long-term complications, including:

Infertility: Untreated Chlamydia and Gonorrhea can cause damage to thefallopian tubes in women, leading to infertility or ectopic pregnancy (CDC, 2021).

Chronic Pelvic Pain: Can be a result of recurrent or untreated PelvicInflammatory Disease (CDC, 2021).

Increased Risk of HIV Acquisition: Other STIs, especially those causing ulcers,can increase the risk of acquiring and transmitting HIV (CDC, 2021).

Cancer: Certain HPV types are associated with cervical, anal, oral, and throatcancers. Hepatitis B and C are linked to liver cancer (CDC, 2021).

Infant Health Problems: Mother-to-child transmission of STIs can lead to seriousheath problems for the infant, including blindness, deafness, brain damage, and death (CDC, 2021).

Overall, the prognosis emphasizes the importance of regular screening, early diagnosis, prompt treatment, and partner management to reduce the negative health consequences of STIs (CDC, 2021).

Future Medications and Therapeutic Innovations

The field of Sexually Transmitted Infections (STIs) treatment is undergoing continuous development, driven by the need to overcome antimicrobial resistance, improve treatment efficacy, and provide more convenient options for patients. Currentresearch focuses on developing new drugs, preventive and therapeutic vaccines, and innovative strategies for pre-exposure and post-exposure prophylaxis (CDC, 2021).

1. New Antibiotics to Combat Resistance

Antimicrobial resistance poses a significant challenge in the treatment of bacterial STIs, especially Gonorrhea. Efforts are focused on developing new classes of antibiotics or repurposing existing drugs:

Gonorrhea Treatments: Given the increasing resistance of *Neisseria gonorrhoeae* to available antibiotics, there is an urgent need for new drugs. Research is underway on compounds such as Zoliflodacin and Cefiderocol, whichhave shown promising results in clinical trials against resistant Gonorrhea strains(CDC, 2021).

Mycoplasma genitalium Treatments: With increasing resistance of *Mycoplasma genitalium* to macrolides and fluoroquinolones, alternative drugs or new

combination therapies are being explored. Research focuses on understandingresistance mechanisms to develop targeted treatments (CDC, 2021).

2. Preventive and Therapeutic Vaccines

Vaccines are powerful tools for preventing infectious diseases, and there are intensive efforts to develop vaccines against STIs for which no vaccines are currently available:

Gonorrhea Vaccine: Several vaccine candidates against Gonorrhea are under development, targeting bacterial surface proteins to prevent infection or reduce its severity. Some vaccines used against meningococcal meningitis (which resembles *Neisseria gonorrhoeae*) show some cross-protection against Gonorrhea (CDC, 2021).

Chlamydia Vaccine: No vaccine is currently available for Chlamydia, but research is ongoing to develop vaccines targeting *Chlamydia trachomatis*proteins to prevent infection or reduce complications (CDC, 2021).

Genital Herpes Vaccine: Although vaccines against Herpes Simplex Virus (HSV) are in early stages of development, no commercially available effective vaccine iscurrently available to

prevent genital herpes (CDC, 2021).

HIV Vaccine: Despite significant progress in antiretroviral therapy, developing aneffective HIV vaccine remains a top priority. Research focuses on inducing broad immune responses that can neutralize different viral strains (CDC, 2021).

3. Pre-Exposure Prophylaxis (PrEP) and Post-Exposure Prophylaxis(PEP)

Pre-Exposure Prophylaxis (PrEP) and Post-Exposure Prophylaxis (PEP) strategies are highly effective in preventing HIV transmission, and similar applications are being explored for other STIs:

STI PrEP: The use of antibiotics (such as doxycycline) as pre-exposure prophylaxis (Doxy-PEP) is being investigated to reduce the risk of Chlamydia,Gonorrhea, and Syphilis in high-risk groups. Studies have shown promising results in reducing the incidence of these diseases (CDC, 2021).

STI PEP: Similar to HIV PEP, the use of antibiotics after sexual exposure is beingevaluated to reduce the risk of bacterial STIs (CDC, 2021).

4. Gene Therapy and Immunotherapies

Gene therapy and immunotherapies are promising research areas for chronic STIssuch as HIV and Herpes:

Gene Therapy for HIV: Some research aims to modify a patient's immune cells tomake them resistant to HIV infection, or to enable the body to produce neutralizing antibodies (CDC, 2021).

Immunotherapies for Herpes: Focus on enhancing the immune system's response to control the virus and reduce the frequency of outbreaks (CDC, 2021).

5. Point-of-Care Testing (POCT)

Developing rapid point-of-care tests is crucial for improving early detection and prompt treatment, thereby reducing transmission. Research focuses on developingrapid and accurate tests that can be performed outside the laboratory (CDC, 2021).

These developments demonstrate a global commitment to combating STIs and offerhope for a future where these diseases are more preventable and treatable (CDC, 2021).

Recommendations

Controlling Sexually Transmitted Infections (STIs) requires a comprehensive and multifaceted approach that combines prevention, early diagnosis, effective treatment, partner management, and health education. Based on available information and ongoing challenges, the following recommendations can be made:

1. Enhance Health Education and Awareness

Comprehensive Education Programs: Implement comprehensive health education programs on STIs in schools and communities, focusing on transmission routes, the importance of safe sexual practices, early diagnosis, andtreatment. These programs should be age-appropriate and culturally sensitive (CDC, 2021).

Public Awareness Campaigns: Launch public awareness campaigns targetinghigh-risk populations, including youth and marginalized groups, to increase

awareness of risks, encourage regular screening, and reduce the stigmaassociated with STIs (CDC, 2021).

2. Expand Screening and Diagnosis

Routine Screening: Integrate routine STI screening into primary healthcare, especially for sexually active individuals and high-risk groups. Screening should be accessible, convenient, and confidential (CDC, 2021).

Point-of-Care Tests (POCT): Invest in the development and deployment of rapidand accurate point-of-care tests for STIs, enabling immediate diagnosis and treatment at the same visit, thereby reducing loss to follow-up and interrupting the chain of transmission (CDC, 2021).

Partner Screening: Encourage the screening and treatment of sexual partners ofindividuals diagnosed with STIs to prevent reinfection and curb their spread (CDC, 2021).

3. Improve Access to Treatment and Care

Prompt Treatment: Ensure immediate access to appropriate and effective treatment for individuals diagnosed with STIs. Medications should be availableand affordable (CDC, 2021).

Antimicrobial Resistance Management: Develop and implement strategies to monitor antimicrobial resistance patterns of STIs and guide treatment based onlocal resistance patterns. Invest in research and development of new drugs to combat increasing resistance (CDC, 2021).

Comprehensive Care: Provide comprehensive care for individuals with STIs,including counseling, psychological support, and reproductive health services(CDC, 2021).

4. Strengthen Prevention Strategies

Condoms: Promote the consistent and correct use of condoms as an effectivemeans of preventing most STIs (CDC, 2021).

Vaccinations: Expand vaccination programs against Human Papillomavirus (HPV) and Hepatitis B, and invest in the development of new vaccines againstother STIs (CDC, 2021).

Pre-Exposure Prophylaxis (PrEP) and Post-Exposure Prophylaxis (PEP): Expand the use of PrEP and PEP for HIV, and explore similar applications forbacterial STIs, such as Doxy-PEP, for high-risk groups (CDC, 2021).

Male Circumcision: Promote male circumcision in regions with high rates of HIV and other

STIs, as studies have shown it reduces the risk of acquiring certain STIs(CDC, 2021).

5. Research and Development

Investment in Research: Increase investment in research and development fornew drugs, vaccines, innovative diagnostic methods, and prevention strategies.Research should focus on a better understanding of the epidemiology, biology,and immunology of STIs (CDC, 2021).

International Collaboration: Foster international collaboration and the exchange of information and expertise among countries and organizations tocombat STIs on a global scale (CDC, 2021).

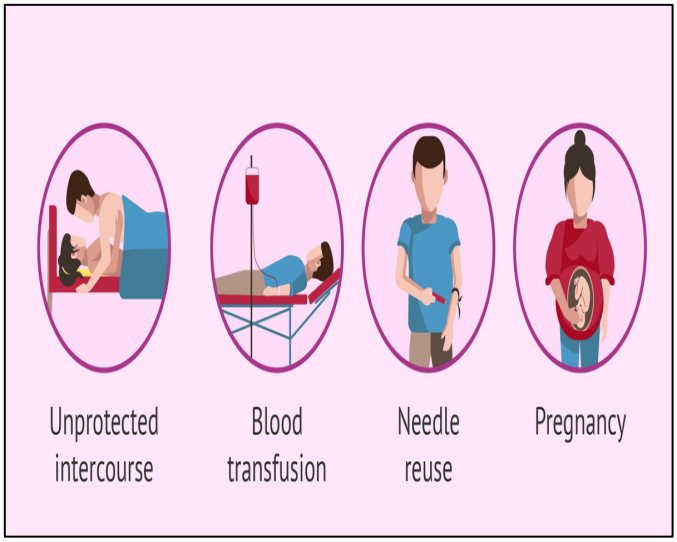
By implementing these recommendations, communities can make significant progressin reducing the burden of STIs and improving sexual and reproductive health worldwide (CDC, 2021).

Tables and Figures

Table 1: Key STI Statistics (2020-2023)

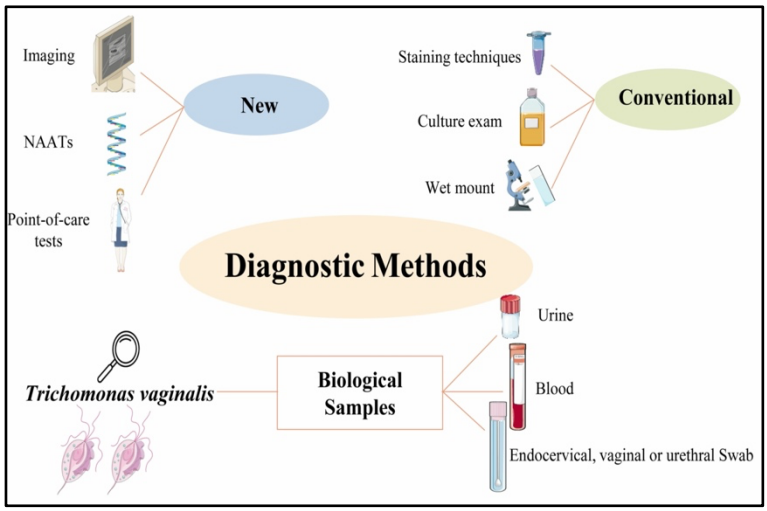
Source	Statistic Type	Value	Notes
CDC (2023)	Total Syphilis, Gonorrhea, andChlamydia Cases	> 2.4 million	Diagnosed and reported in theUnited States
CDC (2023)	Syphilis Cases	> 209,000	In the United States
CDC (2023)	Gonorrhea Cases	> 600,000	In the United States
CDC (2023)	Chlamydia Cases	> 1.6 million	In the United States
CDC (2023)	Congenital Syphilis Cases	3,882	In the United States, including279 stillbirths/infant deaths
WHO (2020)	New infections of Chlamydia,Gonorrhea, Syphilis, or Trichomoniasis	374 million	Among adults aged 15-49globally
WHO (2020)	New cases daily	> 1 million	Among adults aged 15-49globally
WHO (2022)	New Syphilis infections	8 million	Among adults aged 15-49globally
WHO (2022)	Congenital Syphilis Cases	700,000	Globally
CDC (2012-2016)	HPV-associated cancers	34,800	New cases annually in theUnited States
CDC (pre-vaccine)	HPV-associated genital warts	355,000	New cases annually in theUnited States

Figure 1: Sexually Transmitted Infection Transmission Routes



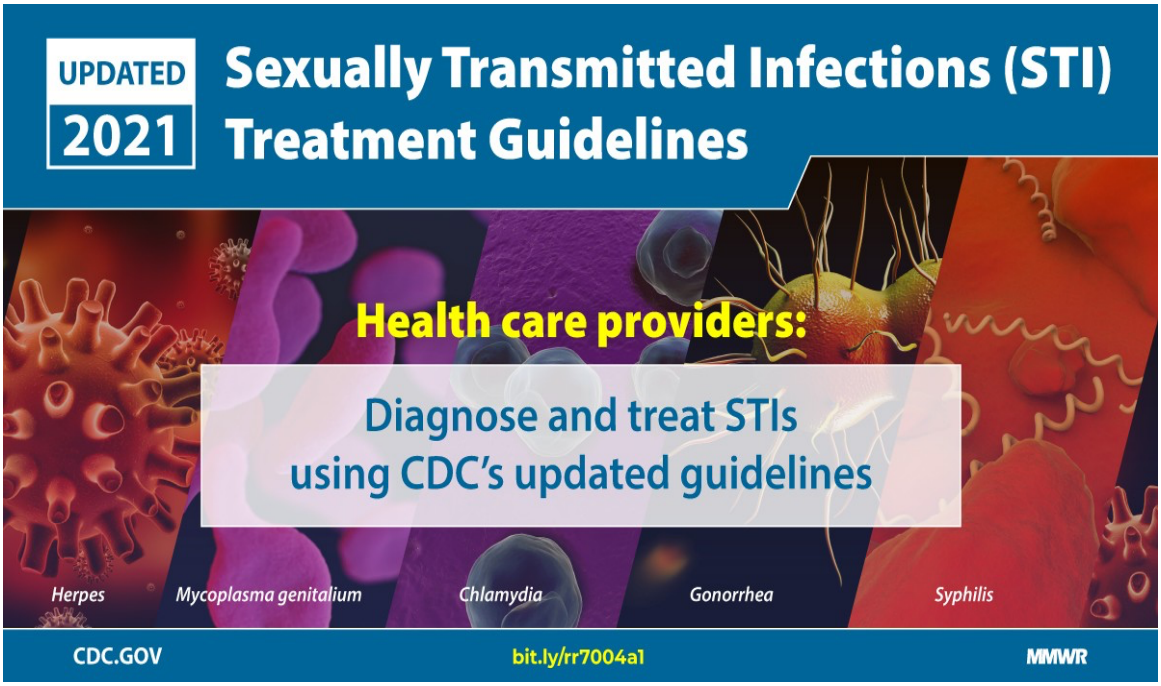
Description: This figure illustrates the main transmission routes of sexually transmitted infections, including unprotected sexual contact, blood transfusion, needle reuse, and mother-to-child transmission during pregnancy.

Figure 2: Sexually Transmitted Infection Diagnosis Methods



Description: This figure illustrates various diagnostic techniques used to detect sexually transmitted infections, ranging from wet mount microscopy to Nucleic Acid Amplification Tests (NAATs).

Figure 3: Sexually Transmitted Infection Treatment Guidelines



Description: This figure represents the Sexually Transmitted Infection Treatment Guidelines issued by the Centers for Disease Control and Prevention (CDC), providing updated recommendations for healthcare professionals.

References

[1] Centers for Disease Control and Prevention. (2021). *Sexually Transmitted Infections Treatment Guidelines, 2021*. U.S. Department of Health and Human Services. https://www.cdc.gov/std/treatment-guidelines/STI-Guidelines-2021.pdf

[2] World Health Organization. (n.d.). *Global and regional STI estimates*. Retrieved from https://www.who.int/data/gho/data/themes/topics/global-and-regional-sti-estimates

[3] Centers for Disease Control and Prevention. (2023). *National Overview of STIs in 2023*. Retrieved from https://www.cdc.gov/sti-statistics/annual/summary.html

Review Article

Moringa oleifera: Promising Gut Microbiome Promotor, Immun-modulator and Natural Antimicrobial

Sohier M. Syame, Ashraf S. Hakim and Hussien A. Abouelhag

Department of Microbiology and Immunology, National Research Centre, 33 Bohouth St., Dokki, Cairo, Egypt

Corresponding author: Sohier M. Syame **E-mail:** sohiersyame@yahoo.com

Received: 29-07-2025, **Accepted:** 16-08-2025. **Published online:** 23-08-2025
DOI: https://doi.org/10.33687/ricosbiol.03.08.71

Abstract

Moringa oleifera, is a rich source of variant bioactive compounds, which exert remarkable immune-modulatory impacts by regulating immune cell activity and cytokine output. Interestingly, Moringa-derived water-soluble polysaccharides activate the gut-associated immune system through beneficial modulation of gut microbiota composition, increasing genera such as Muribaculaceae and Lactobacillus. Furthermore, *M. oleifera* exhibits potent antimicrobial capabilities by enhancing endogenous defenses, reactive oxygen species. In conclusion, underscore *M. oleifera* is potential to promote illness competing and immune function.

Key words: *Moringa oleifera* – antimicrobial - anticancer – immunomodulation- microbiome.

Introduction

A trend plant, *Moringa oleifera* (*M. oleifera* MO), holds remarkable promise because of richness in nutrient component, and high protein biological value (Chen *et al*., 2020). It comprises flavonoid and phenolic components that have been accompanied with promoted health, feed conversion efficiency get better (Rizwan *et al*., 2022). Studies have exposed the advantageous impacts of M. OLEIFERA on the human health (Kou *et al*., 2018). Flavonoids are considered the prime phenolic compounds as secondary metabolites in M. OLEIFERA leaves (Oldoni *et al*., 2019). Flavonoids' compounds exert beneficial action versus a broad scope of clinical illnesses and microbiological activity, potent antioxidant (Mukhopadhyay and Prajapati, 2015). Abundant uses have been recognized for *M. oleifera*, antimicrobial, anti-bacterial, anti-fungal and anti-tumor activity (Barahuie *et al*., 2023).

Gut health

Recently, abundant researches have displayed the significant role of gut microbiota in human health (Gonz´alez Olmo *et al*., 2021 and Loo *et al*., 2020). It is known that the majority of plants' oligo and polysaccharides not be digested in the upper gastrointestinal

tract, so be digested or processed by intestinal bacteria (Shang *et al*., 2018). This process has prompted the growth of bacterial microbiota that produce beneficial metabolites as short chain fatty acids, which are useful to host metabolism, particularly gastrointestinal health (Shi *et al*., 2015).

Several reports demonstrated the beneficial impacts of *M. oleifera* extracts on gut health and maintenance of intestinal homeostasis (Dou *et al*., 2019 and Jaja-Chimedza *et al*., 2018). *Moringa* polysaccharides have improved intestinal integrity, increased mucosal thickness and villus height in the duodenum, ileum and colon in addition to crypt depth ratio in the ileum and jejunum (Wang *et al*., 2019 and Tian *et al*., 2021). Also, moringa polysaccharides enhance the activity of digestive enzymes, amylase, alkaline phosphatase, lipase and trypsin enzymes (Kaur *et al*., 2015). so consequently reflect the digestive function (Adorian *et al*., 2019). Furthermore, moringa polysaccharide improves the diversity of the gut microbiota and the flora structure by elevating the number of beneficial bacteria and reducing the number of harmful bacteria (Dou *et al*., 2019 and Jaja-Chimedza *et al*., 2018). Administration of moringa polysaccharides greatly diminished the serum diamine oxidase, D-lactate and tumor necrosis factor-α (TNF- α), agents which induce intestinal damage (Wang *et al*., 2019). These biological activities of moringa polysaccharides facilitate new approaches for metabolic illnesses therapy and the conservation of human health. A study reported that oral supply of ethanolic root-bark extract of *M. oleifera* has valuable antiulcer and antisecretory effects and is potentially used as a source for antiulcer therapy (Choudhary *et al*., 2013).

A study investigated the impacts of *M. oleifera* polysaccharide (MOP) on immune organ indicators and colonic microbiomics in 21 newborn calves for 8 weeks. Calves were humanely electroshocked on the last day of the trial and slaughtered afterwards. Thymus, spleen, blood and colonic contents were collected for further testing. The results displayed that MOP significantly elevated IgA, IgG, and IgM levels at serum immunity level (Zhao *et al*., 2023).

Gut microbiota modulation

Immunomodulation comprises the targeted manipulation of the immune system to, primarily resulting in improved illness resistance and overall health (Byrne *et al*., 2023). Dietary immunomodulation includes the integration of particular nutrients and bioactive components into animal feed to optimize immune performance (Bobeck *et al*., 2020).

Gut-associated immune system activation

The gut, being the biggest immunological organ, employs a substantial role both in nutrient absorption and digestion (Mohai *et al*., 2025). The intestine of mammals encompasses a plenty and complex population of microorganisms, involving billions of bacteria (Min *et al*., 2020). These microbes play a pivotal role in digestion and nutrient absorption, contributing significantly in the body's immune job (Lu *et al*., 2020). Any

alterations in intestinal flora can cause pathological alterations within the intestinal tissue. Furthermore, such disruption can lead to the output of carcinogenic compounds and chronic inflammation, thereby inducing a remarkable risk to health (Singh *et al*., 2023).

Polysaccharides present in *M. oleifera* have been associated with various biological activities, comprising immune-modulatory impacts, and possible antimicrobials effect (Mohamed Husien *et al*., 2022).

Liu *et al*. (2018) demonstrated immune-modulatory activity of MOP-2 extracted from *M. oleifera* leaves in vitro.The immune-modulatory activity of *M. oleifera* leaf polysaccharides has been reported in abundant studies. For instance, Mohamed Husien *et al*. (2022) has displayed that high doses of MOP improve intestinal health in UC mice by promoting gut microbiome compositions.

As lactobacilli do a beneficial role in immunomodulation (Elabd *et al*., 2018). The study demonstrated that treatment with MOLP-H lead to elevated Lactobacillus levels (Husien *et al*., 2024). Treatment with MOLP initiates alterations in the gut microbiota constitution, particularly elevating the abundance of beneficial families which have been recognized to support greater activity of natural killer (NK) cells (Wen *et al*., 2022). The innate immune system depends on NK cells to perform identification and removal of abnormal infected cells (Cooper *et al*., 2009). On the other side, studies employing mice demonstrated that MOP administration reduced the growth levels of pathogenic bacterium Helicobacter which implemented in different gastric abnormalities (Husien *et al*., 2024 and Wen *et al*., 2022).

Immunomodulatory effect

Some studies have pointed to the immunomodulatory prospect of moringa polysaccharides. A study used polysaccharide obtained by *M. oleifera* leaves hot water extract and displayed significant proliferative activity in macrophages. Also, moringa polysaccharide enhanced the pinocytic capacity of RAW 264.7 cells and boosted the formation of reactive oxygen radicals, nitric oxide and interleukin-6 molecules in a dose-dependent manner (Dong *et al*., 2018). Ultimately, moringa polysaccharide can be achieved as a potent immuno-modulator, and when taken, it can improve the host's humoral and cell-mediated immunity (Li *et al*., 2020).

Anticancer effect

M. OLEIFERA includes the source of naturally important bioactive compounds that act synergistically in their therapeutic action (Tiloke *et al*., 2018). Exposure to chemical or environmental stresses causes accumulation of free radicals and increased production of inflammatory mediators involved in cancer genesis (Mehta *et al*., 2003). It has been mentioned in the studies that the M. OLEIFERA extract has high anti-cancer activity (Al-Asmari *et al*., 2015, Anwar *et al*., 2007 and Bharali *et al*., 2003), and can target some proteins and molecules to prohibit the progression of the cancer cell (Tiloke *et al*., 2018 and Karim *et*

al., 2016). M. OLEIFERA has the prospect in the development of a novel alternate and complementary therapeutic agent to fight cancer (Karim *et al*., 2016). Al-Asmari *et al*., (2015) mentioned that M. OLEIFERA extracts can be used as a valuable agent for the treatment of aggressive breast and colorectal carcinoma (Rock *et al*., 1996). A study reported that there is evidence that Dallose (present in leaves of *Moringa*) inhibits the growth of cancer cells at G1 phase without exerting appreciable effects on normal cells (Yamaguchi *et al*., 2008). The GC-MS analyses demonstrated abundant anti-cancer compounds present in the extracts of leaves and bark of M. OLEIFERA. In instance, hexadecanoic acid found in the leaves, seeds and shell of M. OLEIFERA exhibits selective cytotoxicity versus human leukemic cells. Eugenol present in the M. OLEIFERA shell has a potent anticancer effect versus leukemia, melanoma, osteosarcoma, stomach cancer, skin tumor, mast cells and prostate cancer (Al-Asmari *et al*., 2015). M. OLEIFERA seed extracts have been reported to be efficient on hepatic carcinogen metabolizing enzymes and skin papillomagenesis (Anwar *et al*., 2007 and Bharali *et al*., 2003). Furthermore, M. OLEIFERA leaves combat pancreatic cancer cells (Tiloke *et al*., 2018). Flavonoids have anticancer activity by either stopping the cell cycle as breast cancer or stimulating apoptosis to the cancer cells, downregulation of heat shock protein 90 expression in prostate cancer cells (Hertzog *et al*., 2012). The regulation of mitogen and prime signaling pathways linked to the cancer growth. Certain flavonoid compounds have a highly differentiating effect, acting on malignant cells and not affect normal cells [125, 126] (Luo *et al*., 2011 and Chen *et al*., 2013).

Antimicrobial activity of *Moringa*

Antiviral

M.O. exhibits suppressive activity versus early antigen activation of Epstein-Barr virus (Lim *et al*., 2012). It is reported that M. OLEIFERA dry leaf dust support the immune system against infections and thus elevates the well-being of HIV+ people (Burger *et al*., 2002). Furthermore, M. OLEIFERA extracts have beneficial impacts versus SARS-CoV-2 (Mathpal *et al*., 2021) and influenza (Xiong *et al*., 2021), also reduced the expression of hepatitis B virus cccDNA by 80% (Waiyaput *et al*., 2012). It was shown that ethanol extract of M. OLEIFERA exhibited potent inhibitory impacts versus viral growth *in vitro* studies (Aljofan *et al*., 2014).

Antibacterial

The aqueous, chloroform, ethyl acetate and methanol extracts of M. OLEIFERA have been found to affect the bacteria of *Escherichia coli, Salmonella typhi, Pseudomonas aeruginosa, Enterobacter cloacae, Proteus vulgaris, Klebsiella aerogenes, Shigella, Bacillus cereus, Bacillus subtilis, Klebsiella pneumoniae, Streptococcus pyogenes, Vibrio cholera, Salmonella enterica, Staphylococcus aureus, Citrobacter freundii,* and *Pseudomonas fluorescens* and acid –fast bacteria (Gupta *et al*., 2018, Pal *et al*., 2014, Planta *et al*., 2015, Singh *et al*., 2014, Zaffer *et al*., 2014). It can be assumed that M. OLEIFERA may be a prospect source for the treatment of numerous infections caused by resistant microbes (Planta

et al., 2015 and Zaffer *et al*., 2014). Furthermore, tannins (which are abundant in dried M. OLEIFERA leaves) have significant anti-bacterial action via either privation of the substrates needed for microbial growth or direct effect on microbial metabolism (Ekambaram *et al*., 2016).

Antifungal

The extracts of M. OLEIFERA prohibit the growth of pathogens of subcutaneous phycomycosis in humans and animals. The antifungal performances of various ingredients of the plant involving leaves and seeds have been reported versus fungi such as *Trichophyton interdigitale*, *Aspergillus flavus*, *Penicillium sp.*, *Aspergillus niger*, *Aspergillus oryzae*, *Aspergillus terreus*, *Aspergillus nidulans*, *Fusarium solani*, *Rhizoctonia solani*, *Cladosporium cladosporioides*, *Penicillium sclerotigenum*, *Trichophyton rubrum*, *Microsporum canis* (Asgarpanah *et al*., 2017). The ethanolic extract of leaves revealed antifungal activity against a number of dermatophytes (Jaiswal *et al*., 2009). Moreover, it was found that supplementation of *M. oleifera* leaf powder to aflatoxic contaminated feed, can improved serum liver enzymes and hepatic antioxidant status in broilers, so it has been considered a potential combating to aflatoxin exposure (Umaya *et al*., 2012).

Conclusion

M. oleifera is greatly identified as a promising solution for sustainable health conditions because of its rich nutritional composition and therapeutic merits. Its immune-modulatory impacts via regulation of gut immunity and minimize oxidative stress, improving illness resistance. MOP could regulate the intestinal flora, increasing the relative abundance of beneficial bacteria and decreasing the relative abundance of undesirable bacteria, exposing a positive impact on the intestine. Furthermore, antimicrobial activities of *M. oleifera* have been established rendering their usage as alternative to classical antibiotics facilitating the overcoming on global antibiotic resistance concern.

References

Adorian T.J., H. Jamali, H.G. Farsani, P. Darvishi, S. Hasanpour, T. Bagheri and R. Roozbehfar (2019). Effects of probiotic bacteria bacillus on growth performance, digestive enzyme activity, and hematological parameters of Asian Sea bass, Lates calcarifer (Bloch), Probiotics Antimicrob. Proteins 11 (1), 248–255.

Al-Asmari, A.K., Albalawi, S.M., Athar, M.T., Khan, A.Q., Al- Shahrani, H. and Islam, M. (2015). *Moringa oleifera* as an anti-cancer agent against breast and colorectal cancer cell lines. *PLoS One*, *10*(8)e0135814

Aljofan, M., Netter, H.J., Aljarbou, A.N., Hadda, T.B., Orhan, I.E., Sener, B. and Mungall, B.A. (2014). Anti-hepatitis B activity of isoquinoline alkaloids of plant origin. *Arch. Virol., 159*(5), 1119-1128.

Anwar, F., Latif, S., Ashraf, M. and Gilani, A.H. (2007). *Moringa oleifera*: A food plant with multiple medicinal uses. *Phytother. Res.*, *21*(1), 17-25.

Asgarpanah J., Hashemi S.J., Hashemi E. and Askari K. (2017). In vitro antifungal activity of some traditional Persian medicinal plants on pathogenic fungi. Chin. J. Integr. Med., 23(6),433-437.

Barahuie F., Dianat T., Ghaderi Nejad N., Shahbakhsh M. and Kordi Tamandani D.M. (2023). Evaluation of Chemical, Biochemical and Anti-Microbial Effects of *Salvadora persica* and *Moringa oleifera* Extract to Produce Organic Disinfectant Products. Arch. Razi. Inst., 78(4),1379-1386.

Bharali, R., Tabassum, J., Azad, M.R. (2003). Chemomodulatory effect of *Moringa oleifera*, Lam, on hepatic carcinogen metabolising enzymes, antioxidant parameters and skin papillomagenesis in mice. *Asian Pac. J. Cancer Prev., 4*(2), 131-139. PMID: 12875626

Bobeck EA. (2020). Nutrition and health: companion animal applications: functional nutrition in livestock and companion animals to modulate the immune response. J. Anim. Sci., 98,1–8.

Burger, D., Fuglie, L. and Herzig, J. (2002). The possible role of Moringa oleifera in HIV/AIDS supportive treatment. In: International Conference on AIDS.

Byrne K.A., Loving C.L., McGill J.L. (2020). Innate immunomodulation in food animals: evidence for trained immunity? Front Immunol. 11,1099.

Chen X. (2020). Current status and potential of *Moringa oleifera* leaf as an alternative protein source for animal feeds. Front. Vet. Sci., 7,53.

Chen, A.Y. and Chen, Y.C., (2013). A review of the dietary flavonoid, kaempferol on human health and cancer chemoprevention. Food Chem. 138, 2099–2107.

Choudhary M.K., Bodakhe S.H., Gupta S.K. (2013). Assessment of the antiulcer potential of Moringa oleifera root-bark extract in rats. J Acupunct Meridian Stud., 6,214-20.

Cooper M.A., Colonna M. and Yokoyama W.M. (2009). Hidden talents of natural killers: NK cells in innate and adaptive immunity. EMBO Rep. 10,1103–10.

Dong Z., C. Li, Q. Huang, B. Zhang, X. Fu and R.H. Liu. (2018). Characterization of a novel polysaccharide from the leaves of Moringa oleifera and its immunostimulatory activity, J. Funct. Foods, 49, 391–400.

Dou Z., C. Chen and X. Fu (2019). Bio-accessibility, antioxidant activity and modulation effect on gut microbiota of bioactive compounds from Moringa oleifera lam. Leaves during digestion and fermentation in vitro, Food Funct., 10(8), 5070–5079.

Ekambaram S.P., Perumal S.S. and Balakrishnan A. (2016). Scope of Hydrolysable Tannins as Possible Antimicrobial Agent. Phytother Res., 30(7),1035-45. .

Elabd EMY, Morsy S.M. and Elmalt H.A. (2018). Investigating of *moringa oleifera* role on gut microbiota composition and inflammation associated with obesity following high fat diet feeding. Open Access Maced J. Med .Sci., 6,1359–64.

Gonz´alez Olmo B.M., M.J. Butler and R.M. Barrientos. (2021). Evolution of the human diet and its impact on gut microbiota, immune responses, and brain health, Nutrients 13 (1), 196.

Gupta, S., Jain, R., Kachhwaha, S. and Kothari, S.L. (2018). Nutritional and medicinal applications of *Moringa oleifera* Lam—Review of current status and future possibilities. *J. Herb. Med.*, *11*, 1-11.

Hertzog, D. and Tica, .O.S., (2012). Molecular mechanisms underlying the anticancerous action of flavonoids. Curr Health Sci. J., 38, 145–149.

Husien HM, Rehman SU, Duan Z. and Wang M. (2024). Effect of *Moringa oleifera* leaf polysaccharide on the composition of intestinal microbiota in mice with dextran sulfate sodium-induced ulcerative colitis. Front Nutr., 11,1–10.

Jaiswal, D., Kumar Rai, P., Kumar, A., Mehta, S. and Watal, G. (2009). Effect of *Moringa oleifera* Lam. leaves aqueous extract therapy on hyperglycemic rats. *J. Ethnopharmacol.*, *123*(3), 392-396.

Jaja-Chimedza A., L. Zhang, K. Wolff, B.L. Graf, P. Kuhn, K. Moskal and I. Raskin, A. (2018). dietary isothiocyanate-enriched moringa (*Moringa oleifera*) seed extract improves glucose tolerance in a high-fat-diet mouse model and modulates the gut microbiome, J. Funct. Foods 47, 376–385.

Karim, N.A.A., Ibrahim, M.D., Kntayya, S.B., Rukayadi, Y., Hamid, H.A. and Razis, A.F.A. (2016). *Moringa oleifera* Lam: Targeting chemoprevention. *Asian Pac. J. Cancer Prev., 17*(8), 3675-3686. PMID: 27644601

Kaur, G., Invally, M., Sanzagiri, R. and Buttar, H.S. (2015). Evaluation of the antidepressant activity of *Moringa oleifera* alone and in combination with fluoxetine. J. Ayurveda Integr. Med., 6, 273.

Kou, X., Li, B., Olayanju, J.B., Drake, J.M. and Chen, N. (2018). Nutraceutical or pharmacological potential of *Moringa oleifera* lam. Nutrients, 10, 343.

Li C., Z. Dong, B. Zhang, Q. Huang, G. Liu and X. Fu. (2020). Structural characterization and immune enhancement activity of a novel polysaccharide from *Moringa oleifera* leaves, Carbohydr. Polym. 234, 115897.

Lim, T. *Edible Medicinal and Non–Medicinal Plants*, Springer, 2012.

Liu X., Xu Q.X., Wang D.B., Zhao J., Wu Y., Liu Y. and *et al*. (2018). Improved methane production from waste activated sludge by combining free ammonia with heat pretreatment: performance, mechanisms and applications. Bioresour Technol., 268,230–6.

Loo, Y.T. K. Howell, M. Chan, P. Zhang and K. Ng. (2020). Modulation of the human gut microbiota by phenolics and phenolic fiber-rich foods, Compr. Rev. Food Sci. Food Saf. 19 (4), 1268–1298.

Lu D., Huang Y., Kong Y., Tao T. and Zhu X. (2020). Gut microecology: why our microbes could be key to our health. Biomed Pharmacother, 131,110784.

Luo, H., Rankin, G.O., Li, Z., DePriest, L. and Chen, Y.C. (2011). Kaempferol induces apoptosis in ovarian cancer cells through activating p53 in the intrinsic pathway. Food Chem. 128, 513–519.

Mathpal S., Sharma P., Joshi T., Joshi T., Pande V. and Chandra S. (2021). Screening of potential bio-molecules from *Moringa olifera* against SARS-CoV-2 main protease using computational approaches. J Biomol. Struct. Dyn.,1,1–12.

Mehta, K., Balaraman, R., Amin, A.H., Bafna, P.A. and Gulati, O.D. (2003). Effect of fruits of *Moringa oleifera* on the lipid profile of normal and hypercholesterolaemic rabbits. *J. Ethnopharmacol.*, *86*(2-3), 191-195.

Min L, Chi Y. and Dong S. (2020). Gut microbiota health closely associates with PCB153-derived risk of host diseases. Ecotoxicol Environ Saf., 203,111041. doi: 10.1016/j.ecoenv.2020.111041, PMID: [DOI] [PubMed].

Mohai U.d. Din R., Eman S., Zafar M.H., Chong Z., Saleh A.A., Husien H.M. and Wang M. (2025). *Moringa oleifera* as a multifunctional feed additive: synergistic nutritional and immunomodulatory mechanisms in livestock production. Front. Nutr., 20,12,1615349.

Mohamed Husien H., Peng W.L., Su H., Zhou R.G., Tao Y., Huang J.J. and *et al*. (2022). *Moringa oleifera* leaf polysaccharide alleviates experimental colitis by inhibiting inflammation and maintaining intestinal barrier. Front Nutr., 9,1–14.

Mukhopadhyay, P. and Prajapati, A. (2015). Quercetin in anti-diabetic research and strategies for improved quercetin bioavailability using polymer-based carriers–a review. RSC Adv. 5, 97547–97562.

Oldoni, T.L.C., Merlin, N., Karling, M., Carpes, S.T., de Alencar, S.M., Morales, R.G.F., da Silva, E.A. and Pilau, E. (2019). Bioguided extraction of phenolic compounds and uhplc-esi-q-tof-ms/ms characterization of extracts of *Moringa oleifera* leaves collected in Brazil. 125, 108647.

Pal, S.K., Mukherjee, P.K., Saha, K., Pal, M. and Saha, B.P. (1995). Antimicrobial action of the leaf extract of *Moringa oleifera* lam. *Anc. Sci. Life*, *14*(3), 197-199.

Planta medica, Abdallah E.M. (2015). Antibacterial properties of leaf extracts of *Moringa oleifera* Lam. Growing in Sudan. *J. Adv. Med. Pharm. Sci.*, *5*(1), 1-5.

Rizwan N, Rizwan D. and Banday M. (2022). *Moringa oleifera*: the miracle tree and its potential as non-conventional animal feed: a review. Agric Rev., 45,369–379.

Rock, C.L., Jacob, R.A. and Bowen, P.E. (1996). Update on the biological characteristics of the antioxidant micronutrients: vitamin C, vitamin E, and the carotenoids. *J. Am. Diet. Assoc.*, *96*(7), 693-702.

Shang Q., H. Jiang, C. Cai, J. Hao, G. Li and G. Yu. (2018). Gut microbiota fermentation of marine polysaccharides and its effects on intestinal ecology: an overview, Carbohydr. Polym. 179, 173–185.

Shi L.L., Y. Li, Y. Wang and Y. Feng, (2015). MDG-1, an ophiopogon polysaccharide, regulate gut microbiota in high-fat diet-induced obese C57BL/6 mice, Int. J. Biol. Macromol. 81, 576–583.

Singh S., Sharma P., Sarma D.K., Kumawat M., Tiwari R., Verma V. and *et al*. (2023). Implication of obesity and gut microbiome dysbiosis in the etiology of colorectal cancer. Cancers (Basel), 15,1–28.

Singh, K. and Tafida, G. (2014). Antibacterial activity of *Moringa oleifera* (Lam.) leaves extracts against some selected bacteria. *Int. J. Pharm. Pharm. Sci.*, *6*(9), 52-54.

Tian H., Y. Liang, G. Liu, Y. Li, M. Deng, D. Liu, Y. Guo and B. Sun. (2021). *Moringa oleifera* polysaccharides regulates caecal microbiota and small intestinal metabolic profile in C57BL/6 mice, Int. J. Biol. Macromol. 182, 595–611.

Tiloke, C., Anand, K., Gengan, R.M. and Chuturgoon, A.A. (2018). *Moringa oleifera* and their phytonanoparticles: Potential antiproliferative agents against cancer. *Biomed. Pharmacother.*, *108*, 457-466.

Umaya, R.S., Raju, P. and Thimmaiah, V., (2012b). Protective efficacy of *Moringa oleifera* during aflatoxin exposure in broilers. Res. J. Biotechnol. 7, 125–128.

Waiyaput W., Payungporn S., Issara-Amphorn J. and Panjaworayan N.T. (2012). Inhibitory effects of crude extracts from some edible Thai plants against replication of hepatitis B virus and human liver cancer cells. BMC Complement Altern. Med.,12,1–7.

Wang F., Y.F. Bao, J.J. Si, Y. Duan, Z.Bin Weng and X.C. Shen (2019). The beneficial effects of a polysaccharide from moringa oleifera leaf on gut microecology in mice, J. Med. Food, 22 (9), 907–918.

Wen Z., Tian H., Liang Y., Guo Y., Deng M., Liu G. and *et al*. (2022). *Moringa oleifera* polysaccharide regulates colonic microbiota and immune repertoire in C57BL/6 mice. Int J Biol Macromol. (2022) 198,135–46.

Xiong Y., Rajoka M.S.R., Mehwish H.M., Zhang M., Liang N., Li C. and *et al*. (2021). Virucidal activity of *Moringa* A from *Moringa oleifera* seeds against Influenza A Viruses by regulating TFEB. Int Immunopharmacol, 95,1–9.

Yamaguchi, F., Takata, M., Kamitori, K., Nonaka, M., Dong, Y., Sui, L. and Tokuda, M. (2008). Rare sugar D-allose induces specific upregulation of TXNIP and subsequent G1 cell cycle arrest in hepatocellular carcinoma cells by stabilization of p27kip1. *Int. J. Oncol., 32*(2), 377-385.

Zaffer, M., Ahmad, S., Sharma, R., Mahajan, S., Gupta, A. and Agnihotri, R.K. (2014). Antibacterial activity of bark extracts of *Moringa oleifera* Lam. against some selected bacteria. *Pak. J. Pharm. Sci., 27*(6), 1857-1862.

Zhao C., Li H., Gao C., Tian H., Guo Y., Liu G, Li Y., Liu D. and Sun B. (2023). *Moringa oleifera* leaf polysaccharide regulates fecal microbiota and colonic transcriptome in calves. Int. J. Biol. Macromol. 253(Pt 6),127108.

Research Article

Stomach Cancer: Understanding Public Attention to Risk Factors, Warning Signs and Screening Approaches, a Cross-Sectional Survey Study

Israa Abdul Wahhab Ati

National Cancer Institute, Cairo University

Abstract

Stomach cancer (SC) maintains constituting a major cause of cancer-linked mortality globally and its prevalence elevates sharply, screening of the risk factors is important. The study objected to estimate the knowledge of risk factors especially *H. pylori* and warning symptoms and behavior towards SC screening tools among the general population in an Egyptian governorate.

A cross-sectional survey was carried on 876 participants, 512 females and 364 males in Giza city along the period from September 2024 to December 2024 in form of self-designed questionnaire. The questions involve personal and demographic information, the individual's general knowledge about SC potential risk factors, and associated signs. Another group stressed on how likely the participants undergo screening for SC and how important the idea of screening is? Ultimately, determine which sources of health information are the most motivated? The demographic criteria of 876 over 18 years of age responsive participants revealed 58.45% females and 41.55% males, 62.1% in mid-aged, 65.52% not reach college degree and 52% were working. The most recognized risk factors were *H. pylori* infection, smoking and eating a lot of salty, smoked, or pickled foods, obesity were big concerns (64.27%), (62.39%), and (52.05%) respectively. The majority of participants (94.06%) haven't undergone screening despite of 85.16% of the participants believe that screening tests are important for early diagnosis. The main mentioned reason is the cost (62.74%) followed by fear (16.21%). The most mentioned sign linked to SC was stomach pain (75.68%), followed by unexplained weight loss (52.05%). As expected, the main information source was social media and internet (56%) while, healthcare providers constitute only (3.7%). There is an extreme need to elevate the public's awareness about the importance of early screening methods for stomach cancer and enhance trustable information sources as health providers advising.

Keywords: Stomach cancer- risk factors- symptoms- screening-cross-sectional study.

Corresponding author: Israa Abdul Wahhab Ati **E-mail:** R_rosa39@yahoo.com

Received: 29-07-2025, **Accepted:** 16-08-2025. **Published online:** 31-08-2025

DOI: https://doi.org/10.33687/ricosbiol.03.08.72

Introduction

Statement of the Problem

Stomach cancer (SC), also termed as gastric cancer, continues to institute a significant global health concern, and usually ranking among the most common and lethal cancers (Bray *et al*., 2024). Globally, it was recognized as the fifth most prevalent malignancy and the fifth

Research Article

leading reason of cancer-associated deaths in last 5 years. Over the past decades, increasing in the absolute number of new cases was continues to occur in spite of decreasing in global age-standardized incidence and death rates (Li *et al*., 2022). The concentrated burden observed in regions underscore the persistent impact of region-specific risk factors such as high-sodium diets and *Helicobacter pylori* (*H. pylori*) infection as in Egypt (Salem *et al*., 2019). This highlights an enforcement need for targeted public health interferences that are susceptible to varied regional dietary and lifestyle manners, rather than depending on a generalized approach (Thrift and El-Serag, 2020).

In the United States, SC remains a grave challenge, with estimated approximately 30,300 new recognition and 10,780 deaths rates in 2025. The prognosis for SC patients in the U.S. is particularly frustrated, only 36% are related to 5-year survival but decreased to 7% when the cancer is diagnosed at a late stage (Bray et al., 2024). Nevertheless, the prevalence of SC in Egypt has a variant scenario as it is the 12th most noticed cancer in both sexes representing 1.6% of the total malignancies and 2.2% cancer death cases and 55% of cases occur between 50 and 70 years of age (Darwish *et al*., 2016, Ramez *et al*., 2021). This wide survival variance strictly asserts the imperative for efficient prohibition strategies and early recognition.

Extracting from epidemiological view, a remarkable proportion of SC cases is attributed to modifiable risk factors, which their abstractions a cornerstone of illness control (Lu *et al*., 2021). The principle key modifiable factors involve alcohol consumption, *H. pylori* infection, particular dietary patterns as 'high-sodium diets and tobacco use which is known to double the risk of stomach cancer (Boi-Dsane *et al*., 2023).

In spite of, scientific research asserts that SC is largely preventable via lifestyle alterations and regular screening, which could reduce about 60% to 70% of cases, the illness consistent to institute a prime public health concern. So, this ongoing issue indicates to a gap between what people know about prohibiting the disease and actual health actions. If people believe that cancer is a disease could be preventable but in the same time, they do not act on this belief, it proposes that the message is not being translated into practice (Shah *et al*., 2020).

The Importance of the Study

Scientific Importance

This present study is scientifically substantial as, It will provide a current, comprehensive assessment of public understanding regarding stomach cancer's dietary risk factors, screening tools and prevention. The findings will provide empirical data to pinpoint particular knowledge gaps, such as *H. pylori* detection, misunderstandings about diet or, identifying barriers like fear of gastroscopy. This study potentiates significant scientific importance as it will share a present and systematic assessment to the academic literature on public comprehending of stomach cancer.

Applied Importance

The results of the current study will have a significant impact on public health by supplying the evidence required to emerge highly targeted educational programs. By

Research Article

improving public comprehending, the study can encourage more people to join preventive behaviors, as *H. pylori* testing, healthier diets, and smoking cessation. Study can also encourage earlier diagnosis by elevating symptom awareness, an earlier detection is directly associated to better survival rates. The data may also highlight the requirement for more education among healthcare providers.

Objectives of the Study

Primary Objectives

Quantitative assessment of the ongoing level of public understanding concerning dietary risk factors for stomach cancer, high-salt foods, processed meats, low fruits and vegetables intake, and their linked mechanisms of action in gastric carcinogenesis. Evaluation of public awareness of rotted stomach cancer barring strategies. This encompasses understanding the importance of *Helicobacter pylori* abstraction, catching specific dietary modifications, the impact of alcohol and tobacco cessation, and the significance of keeping a healthy body weight.

Secondary Objectives

Identifying other factors, such as age, gender, educational achievement, and income, as well as socioeconomic factors. Determination of the realized barriers that obstruct individuals from taking on the preventive behaviors or looking for early detection of SC. Identifying the main sources from which the public gets their health knowledge about stomach cancer.

Study Questions

To achieve the stated objectives, the following specific study questions will guide the research:

What is the ongoing level of public comprehension of dietary risk factors? and how precise is this comprehension paralleled to scientific proof?

How aware are the people about asserted SC prohibition approaches? including the importance of *Helicobacter pylori* eradication, specific dietary guidelines, tobacco and alcohol control, and maintaining a healthy body weight?

What are the main barriers that impact individuals' wish to embrace stomach cancer preventive approaches or to request early medical concern for potential signs or screening?

What are the most prevalent sources of public about health information and how do these sources affect their understanding of stomach cancer?

Dietary Risk Factors for Stomach Cancer

Dietary factors play a crucial role in the etiology of SC, with extensive epidemiological proof associating particular consumption patterns to illness risk. Understanding these links is pivotal for efficient public health prevention strategies (Richa *et al*., 2022).

High Salt Intake and Salt-Preserved Foods

The increased risk of stomach cancer is strongly linked with consumption of high-salt foods and those preserved with salt because of direct damage to the gastric mucosal cells. High salt concentrations can disrupt the guard mucosal barrier, resulting in inflammation, altered mucin production, and cellular damage. This involved environment elevates the

Research Article

susceptibility of the gastric lining to carcinogens and eases the colonization and activity of a known gastric carcinogen, *H. pylori* (Balendra *et al*., 2023).

Research has displayed a significant rise in SC risk with higher sodium consumption, especially from processed foods, meta-analyses have pointed a statistically remarkable 15% and 24% elevated risk for high salt intake and consumption of salted fish respectively (Yoo *et al*., 2020).

Processed Meats

Consumption of variant processed meats, is consistently associated with an increased risk of SC, particularly non-cardia gastric cancer, while for red meat as a direct etiology is not evident. Nitrates and nitrites can react within the acidic environment of the stomach to form N-Nitroso compounds (NOCs) which are potent carcinogens (Kim *et al*., 2019). Additionally, high-temperature cooking approaches, frying, baking, grilling, or barbecuing meats can produce other carcinogenic compounds, notably polycyclic aromatic hydrocarbons (PAHs) and heterocyclic amines (HCAs) (Mark *et al*., 2005).

Protective Role of Fruits and Vegetables

Conversely, the lower risk of SC is usually linked to a diet rich in a variety of colorful fruits and vegetables, beans, whole grains, poultry and fish because of the abundance of bioactive components within these foods. The research suggests a synergistic impact where a healthy diet not only directly minimizes cancer risk via its antioxidant and anti-inflammatory characteristics but also provides a healthier gastric environment not suitable to *H. pylori*-induced carcinogenesis (Łuszczki *et al*., 2023).

Other Dietary Factors

Notably, there are other dietary elements implemented in SC risk, excessive or even moderate alcohol consumption, greater body fatness and also the consumption of charred foods (Urciuoli, 2016).

Prevention of Stomach Cancer

***Helicobacter pylori* Eradication**

H. pylori is evidently classified as a Class 1 human carcinogen, and its removal is greatly recommended as an effective and cost-efficient policy for minimizing gastric cancer risk, especially in asymptomatic individuals (Sokic-Milutinovic *et al*., 2015). Regarding the pathogenesis of *H. pylori*, the pathogen induces chronic inflammation and damage of the acid-secreting glands in the stomach, which leads to pre-neoplastic lesions as atrophic gastritis and intestinal metaplasia. The pathogen also outputs vacuolating cytotoxin A and cytotoxin-associated gene A, which have direct oncogenic impacts (Kusters *et al*., 2006). Although eliminating *H. pylori* is effective, stomach cancer can still develop, particularly if a person already has intestinal metaplasia (IM). This indicates that there may be an irreversible point in cancer development (Khozani *et al*., 2024). Therefore, public health campaigns should not only stress early detection and eradication of *H. pylori* but also emphasize the need for continued monitoring for high-risk individuals.

Research Article

Lifestyle Modifications

Several lifestyle modifications are substantial for SC prevention. Dietary alterations are essential, rich in fruits, vegetables, and fiber, besides limiting salted, smoked, and poorly preserved foods intake, as well as processed and red meats. Tobacco and alcohol control are also crucial preventive measures with maintaining a healthy body weight and joining regular physical activity (Ko *et al*., 2023).

Early Detection and Screening

Early recognition is a cornerstone of promoting SC survival rates and believed to prohibit a high percentage of cases, actually, there is no current widely implemented standard screening technique for SC. Recently, non-invasive techniques, as oral microbiome analysis, are considered promising approach for early detection (Xia *et al*., 2022).

The disconnection between what people know about cancer prohibition and what they actually do is a prime issue. Numerous people don't get screened because they don't have symptoms, which expose a substantial misunderstanding of early detection. To overcome this, prevention efforts must address both lifestyle alterations and the psychological hurdles to screening (Izzeddin *et al*., 2025).

Methods

A cross-sectional study was carried on 876 participants, 512 females and 364 males randomly selected those deal with public hospitals' out-patient and clinics related to digestive and gastrointestinal complains in Giza city. The study was conducted from September 2024 to December 2024.

A self-designed questionnaire was asked to the public, provided in Arabic, and then translated to English for study writing. The survey was developed on the basis of evaluating the awareness of the general public concerning the subject of SC.

The survey began with acquiring personal and demographic information of each applicant concerning their age, sex, level of education and occupation. Other questions have targeted the individual's general knowledge about the disease, potential risk factors, and related symptoms. Another set focused on how likely the applicants undergo screening for SC and how important the idea of screening is? Finally, assess which sources of health information are the most influential?

Results

Demographics data

A total of 876 responsive participants, 512 females (58.45%) and 364 males (41.55%) answered the questionnaire, only participants over 18 years of age were eligible. The demographic breakdown displayed that 62.1% of participants were aged between 30 and 50 years. Concerning education, nearly two third of the participants (65.5%) not reach college degree. Working participants have constituted 52% and most were males while 33.2% were non worker mostly females table (1).

Research Article

Table 1: Demographic features of participants

Feature	Number	
	Male	Female
	364 (41.55%)	512 (58.45%)
Age		
18-29	42	68
30-39	132	182
40-49	96	134
50-59	54	72
≥60	40	56
Education		
Non- educated	37	92
Main Education	69	168
Secondary school	73	135
University	136	83
Higher level	49	34
Occupation		
Student	18	33
Employed	264	191
Unemployed	44	247
Retired	38	41

General knowledge about cancer

Regarding the general knowledge and prevalence of cancer, 60.3% of participants have a personal or family cancer history. Interestingly, most prevalent cancers are breast in females while lung and prostate cancer in males. On the other side, a very little percentage of participants (8.1%) hear or have knowledge about stomach cancer specifically, most of them have university education or more, table (2).

Table 2: Knowledge about cancer general prevalence or stomach cancer.

Question	Number			
	Male	Female	Total	%
Do you have a personal or family history of any cancer?				
Yes	223	305	**528**	**60.3**
No	35	72	**107**	**12.2**
I don't know	106	135	**241**	**27.5**
Do you hear or have knowledge about stomach cancer?				
Yes	48	23	**71**	**8.1**
No	316	489	**805**	**91.9**

Knowledge of Risk Factors and Prevention

The survey revealed that 32 out of 876 participants (3.6%) have suffered from a stomach cancer condition all have a history of *H. pylori*. Notably, the pathogen constitutes high prevalence rate among participants (61.87%) so it acts as the first and most substantial risk factor for SC. Regarding other risk factors, the participants have proposed that smoking and

Research Article

eating a lot of salty, smoked, or pickled foods were big concerns (64.27%) and (62.39%) respectively, followed by obesity (52.05%). The least ones were diet lack of fruits and vegetables (21.57%) and then alcohol drinking (4.91%). Notably, the low percentage of alcohol consumption answer may due to the absence of information as 72.37% of participants said 'I Don't know', table 3.

Table 3: Awareness about risk factors of stomach cancer.

Question			
How much do you think each of the following contributes to the risk of getting stomach cancer?	Not at all	Possible	I Don't know
Eating a lot of salty, smoked, or pickled foods	53	546	277
Eating very few fruits and vegetables	476	189	211
Smoking cigarettes	75	563	238
Alcohol drink	170	43	634
Being overweight or obese	245	456	175
Are you suffered from signs or diagnosed stomach cancer?			
yes	32		
No	325		
I don't know	519		
Are you diagnosed H. pylori?			
yes	542		
No	103		
I don't know	231		

Awareness of symptoms related to stomach cancer.

This part of the survey engaged knowledge of signs potential to stomach cancer condition. The most known sign was stomach pain (75.68%), followed by unexplained weight loss (52.05%), and heartburn or indigestion (50.9%). Thirty seven percent of participants have proposed that all signs asked about are implemented and related to stomach cancer figure 1.

Awareness about Screening and early detection

Extracting from table (4), 85.16% of the participants believe that screening tests can recognize stomach cancer before signs appear, but on the contrary side, 94.06% never had a medical procedure to screen for stomach cancer. Majority of this side think that the screening methods are so expensive (62.74%), followed by fear of the concept (16.21%). Notably, 15.3% of the cohort said that the screening methods were not recommended by their doctors' figure (2).

Table 4: Knowledge about screening methods and early detection

Question	**Yes**	**No**
Do you believe that screening tests can find stomach cancer before symptoms appear?	746	47
Have you ever had a medical procedure to screen for stomach cancer, such as a gastroscopy?	52	824

Research Article

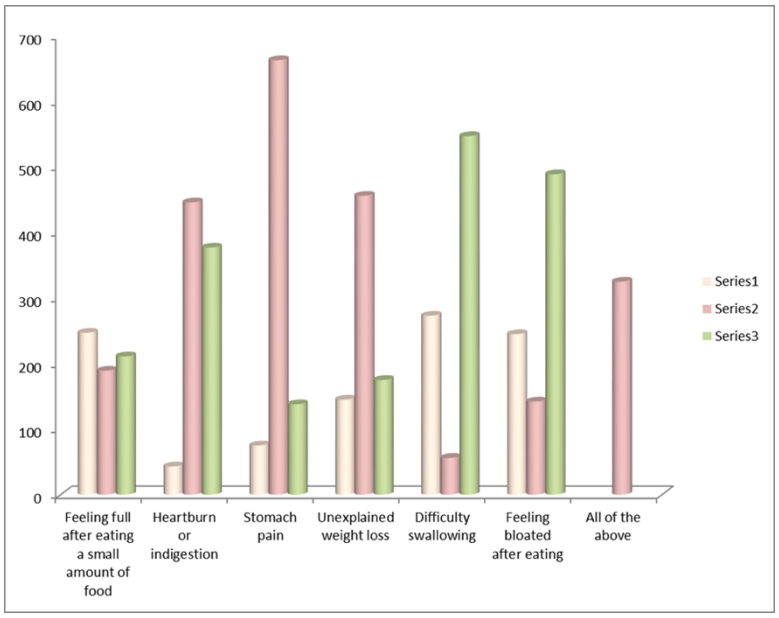


Figure 1: Knowledge of common symptoms related to stomach cancer.
(Series1: Not at all Series 2: Possible Series 3: I Don't know).

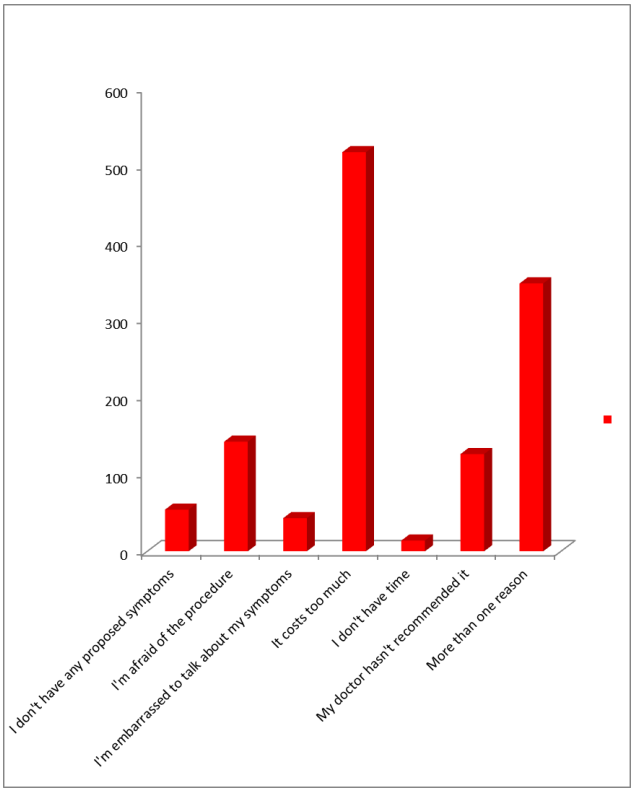


Figure 2: The reasons which prevent participants to perform screening methods

Sources of Information

According to figure (3), 56% of participants had mainly captured their information about cancer from social media and internet (the most are females), persuaded by television and

Research Article

radio media (24.4%), while, it was stubbed that the healthcare providers constitute only (3.7%).

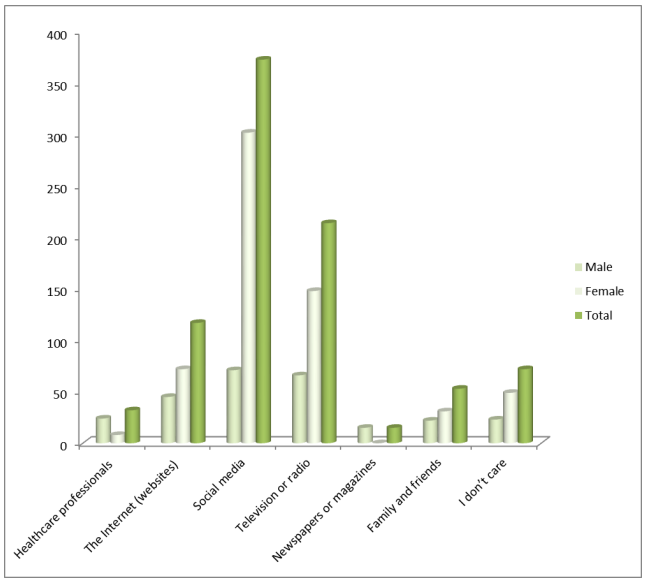


Figure 3: source of information about stomach cancer.

Discussion

Public awareness surveys display a remarkable lack of knowledge about cancer risk factors and signs. For stomach cancer, numerous people miscomprehend risk, this misperception misdirects prevention efforts.

Prime barriers to early diagnosis also subsist (Wang *et al*. 2024).

In current study, 60.3% of participants have a personal or family cancer history with the most prevalent cancers are breast in females while lung and prostate cancer in males. This finding was harmonized with that reported about the common cancer types diagnosed in Egyptian people of both genders (Globocan, 2020). Particularly, the little incidence of stomach cancer mentioned in study was consistent with the Arab world cancer reports (Ibrahim and Shash, 2022).

The study displayed that all participants suffered from stomach cancer condition, have complained or diagnosed *H. pylori*. Moreover, the finding pointed to high prevalence rate of the pathogen among participants (61.87%).

This incidence rate is coincided with global reports which demonstrated the common infection with *H. pylori*, particularly in low- and middle-income countries as pathogen. Also, Duan *et al*., (2025) stated that *H. pylori* influencing an estimated more than 50% of the world's population (Grad *et al*. 2012).

This data asserts the major role of *H. pylori* as the prime risk and causative factor in SC pathogenesis. This is consistent with several studies,

Epidemiologic reports have displayed that people who have chronic *H. pylori* infections have an elevated risk of developing non-cardia gastric adenocarcinoma (Morais *et al*. 2022 and Yao *et al*. 2023), as well as gastric cardia cancer (Han *et al*. 2023 and Yang *et al*. 2021).

Research Article

Additionally, studies have revealed that therapeutic eradication of *H. pylori* infection minimizes the risk of SC in asymptomatic individuals (Li *et al*. 2019), in individuals at rosed risk due to family history (Choi *et al*. 2020), and in those who have had surgery for early SC (Lee *et al*. 2016).

It is believed that nearly all patients with gastric MALT lymphoma expose signs of *H. pylori* infection, and the risk of emerging this cancer is fundamentally greater in affected people than unaffected ones (Parsonnet *et al*. 1994 and de Sanjose *et al*. 2004). The strongest proof binding *H. pylori* infection with gastric MALT lymphoma extracted from studies displaying that when patients with this lymphoma are treated with antibiotics to eradicate *H. pylori*, their tumors shrink (Fischbach *et al*. 2004 and Stathis *et al*. 2009).

The data extracted from current study demonstrated other risk factors associated to SC affection, smoking then eating a lot of salty, smoked, or pickled foods, obesity, lack of fruits and vegetables in diet and alcohol drinking were concerns as 64.27%, 62.39%, 52.05%, 21.57% and 4.91%. These notable findings were corresponded with other previous studies, a number of experimental investigations found that salt had a co- carcinogenic influence when integrated with *H. pylori* infection. A detailed meta-analysis of longitudinal researches exhibited that salt-rich foods have a strong induced effect on the incidence of SC in the general population (D'Elia *et al*. 2014).

Also, pickled foods' consumption which is common dietary practice in Egypt

And also, in other regions in world has been associated with an elevated incidence of SC in meta-analysis observational investigations. The findings implicate that consumption of pickled vegetables/foods may rise the risk of SC by 50% (Ren *et al*. 2012). Smoked food is a well-known source of carcinogenic PAH compounds. Following to epidemiological studies, people who regularly ate smoked-dried salted meats which contain carcinogenic heterocyclic amines had a nearly three-fold increased risk of stomach cancer (Phukan *et al*. 2006).

A meta-analysis performed by Ma et al. (2017) included ten studies revealed that consuming alcohol increases the risk of SC. This may be attributed to the fact that alcohol can act as a solvent, facilitating other toxic compounds to affect upper digestive tract cell lining. This meta-analysis asserted that alcohol intake can raise the risk of SC even at moderate levels.

Also, smoking is considered a notable risk factor implemented in various forms of cancers, not only cancers affecting the gastrointestinal tract (Jacob *et al*. 2018).

With the elevating prevalence of obesity worldwide, findings of a study performed by Ruixin *et al*., (2025) revealed that obesity significantly elevates risk of SC and remarkably affects the treatment of patients. In the same manner, analysis of Korean wide population-based cohort exposed SC risk was the highest in persistent obesity group, persuaded by non-persistent obesity group compared with never-obesity set (Lim *et al*., 2022).

On the other side, alteration in dietary behavior as high fruits and vegetables intake has found to be linked to a lower risk of cancers in over 200 epidemiological case-control and cohort studies. The consumption of fresh vegetables and fruits, which contain antioxidant vitamins, vitamins A and C, caused significant reduction of gastric cancer risk (Bae and Kim, 2016). A study was conducted on 14 case–control studies (5362 cases, 11,497 controls), the

Research Article

findings demonstrated that high dietary vitamin C from adjusted fruit and vegetables intake had reduced SC (Sassano *et al*., 2024).

The findings of present study displayed that participants have suggested stomach pain (75.68%), unexplained weight loss (52.05%), and heartburn or indigestion (50.9%) known as most symptoms proposed to SC. These data were harmonized with other studies, an Omani study investigated the recognition of symptoms of SC as "unexplained weight loss" (48.0%), "frequent bloating and flatulence" (36.8%) and "abdominal pain" (33.8%), (Al-Azri *et al*. 2019). Also, Huang *et al*., (2019) mentioned that unexplained weight loss (69.5%), upper abdominal pain (69.6%) and epigastric distention (66.2%) were the most proposed symptoms of gastric cancer.

Extracting from table (4), in spite of, 85.16% of the participants believe that screening tests can detect stomach cancer prior to appearance of symptoms, 94.06% of them never had a medical procedure to screen for stomach cancer. Majority of this side think that the screening methods are so expensive (62.74%), followed by fear of the concept (16.21%). Notably, 15.3% of the cohort said that the screening methods were not recommended by their doctors.

Huang *et al*., (2019) stated that 80.0% of study participants reported "certainly yes/probably yes" for the importance of screening methods, parallel to the study performed by Wang *et al*., (2024) who reported that a significant part of participants (78.5%) had not joined in GC screening.

The study results which presented in figure (3), showed that 56% of participants had primarily gained their information about cancer from social media and internet (the most are females), followed by television and radio media (24.4%), while, unfortunately the healthcare providers constitute only (3.7%). Wang *et al*., (2024) demonstrated that videos on social media platforms can aid the public knowledge about symptoms, etiologies, causations and treatment methods of SC. However, both videos' content and quality are inadequate.

Conclusion and recommendation

General public knowledge about stomach cancer is poor, several challenges and barriers were existed, low education, low income, extraction the information from non-trustable sources as social media. The link between *H. pylori* infection and GC is highly evident. Early understanding of SC related symptoms and necessity of performing the screening methods for detection of *H. pylori* and early diagnosis of stomach cancer to elevate the rate of curing and survival. Encourage of doctor and other health providers to give proper consultant for population.

References

Ahmed Ramez A., Maha El-Zaafarany, Hayam Ghazy, Refky B., Amany Hassan and Manar Hamed (2021). Early onset gastric cancer in Egyptian patients: Is it really a different clinical entity? IJCBR, 5(2), 173-180.

Al-Azri M., Al-Kindi J., Al-Harthi T., Al-Dahri M., Panchatcharam S.M., and Al-Maniri A. (2019). Awareness of Stomach and Colorectal Cancer Risk Factors., Symptoms and

Research Article

Time Taken to Seek Medical Help Among Public Attending Primary Care Setting in Muscat Governorate., Oman. J Cancer Educ. 34(3),423-434.

Bae J.M., and Kim E.H. (2016). Dietary intakes of citrus fruit and risk of gastric cancer incidence: an adaptive meta-analysis of cohort studies. *Epidemiol Health*., 38,e2016034.

Balendra V., Amoroso C., Galassi B., Esposto J., Bareggi C., Luu J., Scaramella L., and Ghidini M. (2023). High-Salt Diet Exacerbates *H. pylori* Infection and Increases Gastric Cancer Risks. *J. Pers. Med*. 28, 13(9),1325.

Boi-Dsane N.A.A., Amarh V., Tsatsu S.E., Bachelle S.V., Bediako-Bowan A.A.A., Koney N.K., and Dzudzor B. (2023). Cross-Sectional Study for Investigation of the Association Between Modifiable Risk Factors and Gastrointestinal Cancers at a Tertiary Hospital in Ghana. *Cancer Control*. 30,10732748231155702.

Bray F., Laversanne M., Sung H., and et al. (2024). Global cancer statistics 2022: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *Cancer J. Clin*. 74(3),229–63.

Choi I.J., Kim C.G., Lee J.Y., and et al. (2020). Family history of gastric cancer and *Helicobacter pylori* treatment. *New England Journal of Medicine* 382(5),427–436.

D'Elia L., and *et al*. (2014). Dietary salt intake and risk of gastric cancer. In: Zappia V., et al., editors. Advances in nutrition and cancer, vol. 159. Berlin Heidelberg, Springer, p. 83–95.

Darwish H., Amr, S., Wedad, B., and Ahmed, Gh. (2016). 10 years' experience in the treatment of gastric cancer: A single Egyptian Cancer Center (NEMROCK). *Pan Arab Journal of Oncology*, 9 (3), 35-41.

de Sanjose S., Dickie A., Alvaro T., and *et al*. (2004). *Helicobacter pylori* and malignant lymphoma in Spain. *Cancer Epidemiology, Biomarkers & Prevention,* 13(6),944–948.

Duan Y., Xu Y., Dou Y., and Xu D. (2025). Helicobacter pylori and gastric cancer: mechanisms and new perspectives. *J. Hematol. Oncol*. 23, 18(1),10.

Fischbach W., Goebeler-Kolve M.E., Dragosics B., Greiner A., and Stolte M. (2004). Long term outcome of patients with gastric marginal zone B cell lymphoma of mucosa associated lymphoid tissue (MALT) following exclusive *Helicobacter pylori* eradication therapy: Experience from a large perspective series. *Gut,* 53(1),34–37.

Gastric Cancer and Obesity: (2025). Disease Occurrence and Perioperative Treatment. The Journal of Nutrition, 7.

Global Cancer Observatory (Globocan), Egypt fact sheet. 2020. https://gco.iarc.fr/today/data/factsheets/populations/818-egypt-fact-sheets.pdf

Grad Y.H., Lipsitch M., and Aiello A.E. (2012). Secular trends in *Helicobacter pylori* seroprevalence in adults in the United States: Evidence for sustained race/ethnic disparities. *American Journal of Epidemiology,* 175(1),54–59.

Han Z., Liu J., Zhang W., and *et al*. (2023). Cardia and non-cardia gastric cancer risk associated with *Helicobacter pylori* in East Asia and the West: A systematic review, meta-analysis, and estimation of population attributable fraction. *Helicobacter* 16,e12950.

Huang Z., Liu W., Marzo RR., Hu Z., Wong LP., and Lin Y. (2022). High-risk population's knowledge of risk factors and warning symptoms and their intention toward gastric cancer screening in Southeastern China. *Front Public Health*, 10,974923.

Ibrahim, A.H., and Shash, E. (2022). General Oncology Care in Egypt. In: Al-Shamsi, H.O., Abu-Gheida, I.H., Iqbal, F., Al-Awadhi, A. (eds) Cancer in the Arab World. Springer, Singapore.

Research Article

Izzeddin A Bdair, Gladys M L Maribbay, Ola A Bdair, and *et al*. (2025). Awareness of cancer risk factors, protective factors, symptoms and barriers to seek medical advice among adult population. *Asian Pac J. Cancer Prev*., 26 (7), 2345-2352

Jacob L., Freyn M., Kalder M., Dinas K., and Kostev K. (2018). Impact of tobacco smoking on the risk of developing 25 different cancers in the UK: a retrospective study of 422,010 patients followed for up to 30 years. *Oncotarge*t., 9(25),17420-17429.

Kim S.R., Kim K., Lee S.A., Kwon S.O., Lee J.K., Keum N., and Park S.M. (2019). Effect of Red, Processed, and White Meat Consumption on the Risk of Gastric Cancer: An Overall and Dose–Response Meta-Analysis. *Nutrients*, 11(4),826.

Ko K.P. (2024). Risk Factors of Gastric Cancer and Lifestyle Modification for Prevention. *J. Gastric Cancer*, 24(1),99-107.

Kusters J.G., van Vliet A.H., and Kuipers E.J. (2006). Pathogenesis of Helicobacter pylori infection. *Clin. Microbiol. Rev*., 19(3),449-90.

Lee Y.C., Chiang T.H., Chou C.K., and *et al*. (2016). Association between *Helicobacter pylori* eradication and gastric cancer incidence: A systematic review and meta-analysis. *Gastroenterology* ,150(5),1113–1124.e5.

Li F., Hu Y., Guo C., and *et al*. (2022). Economic burden conferred by Population-Level Cancer screening on Resource-Limited communities: lessons from the ESECC trial. *Front Oncol*., 12

Li W.Q., Zhang J.Y., Ma J.L., and *et al*. (2019). Effects of *Helicobacter pylori* treatment and vitamin and garlic supplementation on gastric cancer incidence and mortality: Follow-up of a randomized intervention trial. *BMJ* , 366,l5016.

Lim J.H., Shin C.M., Han K.D., Lee S.W., Jin E.H., Choi Y.J., Yoon H., Park Y.S., Kim N., and Lee D.H. (2022). Association between the Persistence of Obesity and the Risk of Gastric Cancer: A Nationwide Population-Based Study. *Cancer Res Treat*., 54(1),199-207.

Lu L., Mullins C.S., Schafmayer C., Zeißig S., and Linnebacher M. (2021). A global assessment of recent trends in gastrointestinal cancer and lifestyle-associated risk factors. *Cancer Commun* (Lond), 41(11),1137-1151.

Łuszczki E., Boakye F., Zielińska M., Dereń K., Bartosiewicz A., Oleksy Ł., and Stolarczyk A. (2023). Vegan diet: nutritional components, implementation, and effects on adults' health. *Front Nutr*., 9, 10,1294497.

Ma K., Baloch Z., He T-T., and Xia X. (2017). Alcohol consumption and gastric cancer risk: a meta-analysis. *Med Sci Monit*., 23,238–46.

Mark G., Knize James S., Felton James and Felton S. (2005). Formation and Human Risk of Carcinogenic Heterocyclic Amines Formed from Natural Precursors in Meat. *Nutrition Reviews,* 63(5),158-65

Morais S., Costa A., Albuquerque G., and et al. (2022). "True" *Helicobacter pylori* infection and non-cardia gastric cancer, A pooled analysis within the Stomach Cancer Pooling (StoP) Project. *Helicobacter,* 27(3),e12883.

Parsonnet, J., Hansen S., Rodriguez L., and *et al*. (1994). *Helicobacter pylori* infection and gastric lymphoma. *New England Journal of Medicine,* 330(18),1267–1271.

Phukan R.K., Narain K., Zomawia E., Hazarika N.C., and Mahanta J. (2006). Dietary habits and stomach cancer in Mizoram. *India J. Gastroenterol*., 41(5),418–24.

Ren J-S., and et al. (2012). Pickled food and risk of gastric cancer—a systematic review and meta-analysis of English and Chinese literature. Cancer Epidemiol Biomarkers Prev., 21(6),905–15.

Richa, Sharma, N. and Sageena, G. (2022). Dietary factors associated with gastric cancer - a review. *Transl. med. commun.,* **7**, 7.

Research Article

Ruixin Xu., Siwei Pan, Yanqiang Zhang, Can Hu, Zhiyuan Xu, Salem E., Sakr A., Younis F., and Mohamed A. (2019). "Prevalence of Helicobacter pylori infection among farmers and non-farmers with dyspepsia". *Egyptian Journal of Occupational Medicine*, 43, (2), 229-244.

Sassano M., Seyyed Salehi M.S., Collatuzzo G., Pelucchi C., and *et al*. (2024). Dietary intake of vitamin C and gastric cancer: a pooled analysis within the Stomach cancer Pooling (StoP) Project. *Gastric Cancer*, 27(3),461-472.

Shah SC., Nunez H., Chiu S., Hazan A., Chen S., Wang S., Itzkowitz S., and Jandorf L. (2020). Low baseline awareness of gastric cancer risk factors amongst at-risk multiracial/ethnic populations in New York City: results of a targeted, culturally sensitive pilot gastric cancer community outreach program. *Ethn. Health*, 25(2),189-205.

Shirani M., Shariati S., Bazdar M., Sojoudi Ghamnak F., Moradi M., Shams Khozani R., Taki E., Arabsorkhi Z., Heidary M., and Eskandari DB. (2024). The immunopathogenesis of *Helicobacter pylori*-induced gastric cancer: a narrative review. *Front Microbiol*., 15, 1395403.

Sokic-Milutinovic A., Alempijevic T., and Milosavljevic T. (2015). Role of Helicobacter pylori infection in gastric carcinogenesis: Current knowledge and future directions. *World J. Gastroenterol*., 21(41),11654-72.

Stathis A., Chini C., Bertoni F., and *et al*. (2009). Long-term outcome following *Helicobacter pylori* eradication in a retrospective study of 105 patients with localized gastric marginal zone B-cell lymphoma of MALT type. *Annals. of Oncology,* 20(6),1086–1093.

Thrift AP., and El-Serag HB. (2020). Burden of gastric cancer. *Clin Gastroenterol Hepatol*. 18(3),534–42.

Urciuoli B. (2016). Alcohol, cured meats, and obesity play a role in stomach cancer, study finds. *Gastrointestinal Cancers*, (8),1

Wang M., Yao N., Wang J., Chen W., Ouyang Y., and Xie C. (2024). Bilibili, TikTok, and YouTube as sources of information on gastric cancer: assessment and analysis of the content and quality. *BMC Public Health*, 2, 24(1),57.

Wang Q., He X.C., Geng L.X., Jiang S.L., Yang C.J., Xu K.Y., Shen S.F., Cao W.W., Qi W., and Zhao S.P. (2024). Public awareness of gastric cancer risk factors and screening behaviors in Shijiazhuang, China: A community-based survey. *PLoS One*, 19(10),e0311491.

Xia J.Y., and Aadam A.A. (2022). Advances in screening and detection of gastric cancer. *J. Surg. Oncol*., 125(7),1104-1109.

Yang L., Kartsonaki C., Yao P., and *et al*. (2021). The relative and attributable risks of cardia and non-cardia gastric cancer associated with *Helicobacter pylori* infection in China, A case–cohort study. *The Lancet. Public Health,* 6(12),e888–e896.

Yao P., Kartsonaki C., Butt J., and *et al*. (2023). *Helicobacter pylori* multiplex serology and risk of non-cardia and cardia gastric cancer: A case–cohort study and meta-analysis. *International Journal of Epidemiology*, dyad007.

Yoo J.Y., Cho H.J., Moon S., Choi J., Lee S., Ahn C., Yoo K.Y., Kim I., Ko K.P., Lee J.E., and Park S.K. (2020). Pickled Vegetable and Salted Fish Intake and the Risk of Gastric Cancer: Two Prospective Cohort Studies and a Meta-Analysis. *Cancers* (Basel), 12(4),996.