

ISSN E 2959-3751
ISSN P 2959-3743



RICOS BIOLOGY JOURNAL

Vol. 3 no. 7
July, 2025



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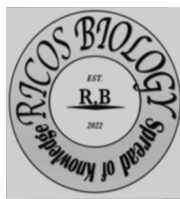
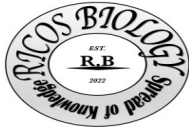


Table of contents

No.	Article	Pages
1	Assessment of individuals' knowledge in the most risky age group for prostate cancer about risk factors and the importance of early screening DOI: https://doi.org/10.33687/ricosbiol.03.07.65	1 - 11
2	Food Contact Material (FCM) Migration Testing; Novel Assay for Ensuring Food Safety. DOI: https://doi.org/10.33687/ricosbiol.03.07.66	12 - 16
3	<i>Streptococcus suis</i>: A Public Health Concern. DOI: https://doi.org/10.33687/ricosbiol.03.07.67	17 - 25



Assessment of individuals' knowledge in the most risky age group for prostate cancer about risk factors and the importance of early screening

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Received: 25-06-2025,

Accepted: 10-07-2025,

Published online: 23-07-2025

DOI: <https://doi.org/10.33687/ricosbiol.03.07.65>

Abstract

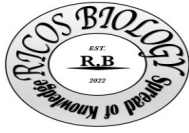
Notably, one of the most prevalent male cancers is prostate cancer (PCa) which considered the second leading reason of globally cancer-associated deaths among males. This study investigated the knowledge about risk factors especially age, and the importance of early screening of PCa among male participants. A cross-sectional questionnaire study was carried on 306 males of whom the majority was between 50–59 years old (41.5%) from January 2025 to March 2025. Around 63.4% of participants were working. The urban participants constitute 78.1%. Most of participants are of university education level (34.3%). Bivariate data were analyzed and relations were deemed significant if the p-value was ≤ 0.05 . The obtained results revealed that 20.9% of participants or their relatives have suffered from a prostate condition. The prostatic enlargement was the most condition reported among the concerned participants (50.0%). On other side, 4.6% had prostate cancer. Family history of prostate conditions was reported in 14.7%. Notably, 94.4% of the participants had an inadequate level of knowledge about both the PSA test and prostate cancer and 96.4% had a negative attitude towards them. The main information source was social media and internet for 47.4% of participants, followed by healthcare providers (25.8%). It was concluded that there was a poor level of knowledge and negative attitude towards screening for prostate cancer and its risk factors among males. This could be attributed to the lack of education and shortage of healthcare providers to focus on the risks of prostate cancer.

Keywords: knowledge - prostate cancer - PSA - awareness - information - age group - risk factors.

Introduction

First: Statement of the Problem

In last decades, prostate cancer (PCa) is a growing life-threatening illness that foremost impacts middle-aged and elderly men with recorded incidences in 105 out of 185 nations (Bray *et al.* 2024). Cornford *et al.* (2024) and Shan *et al.* (2022) reported PCa as the second most prevalent cancers driving to male deaths and ranks as the 5th leading reason of mortalities among all malignant tumors worldwide and also in developing countries (Sung *et al.*, 2021). This notable high death rate can often be referred to inadequate initiatives to raise awareness and knowledge about the value of early PCa screening, which is substantial to diagnose PCa at an early stage and remarkably ameliorate patient survival rates (Rao *et al.*,



2023). Nearly 60% of all PCa are recognized in men at the age of 65 and older (Ferlay *et al.*, 2020). Several risk factors were reported; age above 65 years, race, ethnicity, family history, in addition to less clear factors as diet, obesity, smoking, chemical exposure, prostatitis and sexually transmitted infections (Nelson *et al.*, 2020).

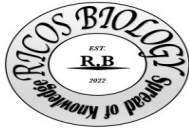
Second: The importance of the study

1. Scientific Importance:

Identifying knowledge gaps: The primary scientific significance relies on its ability to systematically identify particular deficiencies in knowledge among persons within the highest-risk age group concerning prostate cancer. This involves understanding their awareness of potential risk factors (e.g., age, family history, ethnicity) and, definitively, their grasping of the benefits and necessity of early screening. Recognizing these gaps is the backbone step for any targeted intervention. ii. Informing public health strategies and educational programs: By understanding what people don't know, healthcare providers, public health organizations, and policymakers can tailor their messages to address particular misconceptions and assert crucial information. This drives to more effective resource distribution and improved public health outcomes. iii. Understanding barriers to early detection: A lack of knowledge often translates into inaction. The study can shed light on why individuals in the high-risk group may not be engaging in early screening practices. Identifying the potential barriers is substantial for designing interventions that boost proactive health behaviors. iv. Baseline data for intervention assessment: The study may provide valuable baseline data which the effectiveness of future educational interventions can be measured. By performing similar evaluations after an intervention, researchers can scientifically assess whether knowledge levels have improved and whether the intervention was successful in fulfilling its goals. v. Informing clinical practice: Urologists and primary care physicians can employ the study's outcomes to better comprehend their patients' baseline knowledge. This permits them to tailor their patient education during consultations. vi. Contribution to cancer control research: Exploring the human factor in cancer prohibition and early recognition, can drive to the broader field of cancer control research. It considers the behavioral and social determinants of health outcomes, which are increasingly recognized as important for improving public health.

2. Applied importance:

Tailored health information programs: The study's outcomes directly mark the design and implementation of information programs. If, for instance, the study reveals that men in the risky age group are unaware of the obesity predisposition for prostate cancer, informative materials can be particularly developed to confirm this risk factor. This permits for more efficient use of resources by focusing on known knowledge gaps rather than broadly disseminating generic information. ii. Improved screening uptake: By understanding what motivates or prevents individuals from seeking screening (e.g., lack of awareness, fear, misinformation), health campaigns can be designed to overcome these barriers. Higher screening rates mean more early diagnoses, which are crucial for effective treatment. iii.



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Enhanced shared decision-making in clinical settings: Clinicians can use the study's insights to improve their communication with patients. Doctors can adjust their counseling to explain the complexities and empower patients to make informed decisions about their prostate cancer care. iv. Development of culturally sensitive interventions: If the study identifies differences in knowledge levels or attitudes across various cultural or socioeconomic groups within the high-risk age bracket, it highlights the need for culturally sensitive interventions. v. Reduction in advanced-stage diagnoses and mortality: By increasing knowledge about risk factors and the importance of early screening, individuals are more likely to seek timely medical attention, leading to earlier diagnosis when treatment is most effective.

Third: Objectives of the study

Determine the current level of knowledge among individuals in the most risky age group regarding prostate cancer risk factors. 2. Evaluate individuals' understanding of the importance and benefits of early screening for prostate cancer. 3. Identify specific knowledge gaps or misconceptions related to prostate cancer risk factors and early screening within this high-risk population. 4. Explore the sources of information individuals use to learn about prostate cancer. 5. Identify socioeconomic factors associated with varying levels of knowledge. 6. Assess individuals' attitudes and feelings towards prostate cancer screening. 7. Provide baseline data for the development and evaluation of targeted health education programs.

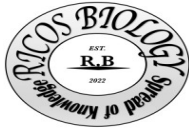
Fourth: Study Questions

How does the individual aware about risk factors such as age, family history, potentially dietary or lifestyle factors as smoking? 2. How does the individual know about the purpose of screening (e.g., early detection, improved prognosis), available screening methods (e.g., PSA test, DRE), and the potential outcomes of early diagnosis? 3. Seeking of pinpoint areas where information is lacking or misunderstood. 4. Understanding where people get their information? (e.g., healthcare providers, internet, friends/family, media) can help optimize future educational efforts. 5. Determining if knowledge levels differ based on age, education, income or other relevant characteristics. 6. How individuals feel about screening, including any fears, anxieties, or perceived barriers that might influence their willingness to undergo screening? 7. How the findings will serve as a foundation for designing effective interventions and improving knowledge and screening behaviors?

Fifth: Literature

1. The relationship between risk factors and prostate cancer

Age, family history, race and genetic predisposition are well-established non-modifiable risk factors for PCa, while obesity, metabolic syndromes, and smoking have been recognized as potential modifiable risk factors. Furthermore, an abundance of environmental, infectious, lifestyle, as well as dietary risk factors may be implemented in the incidence of



PCa (Bergengren *et al.*, 2023). Age is a well-instituted risk factor for PCa. Recent US cancer statistics pointed that the possibility of PCa elevates from 1.8% in men 60–69 yr to 9.0% in men 70 yr and older. Autopsy studies expose that 40% of unscreened men elder than 60 years manifest PCa (Siegel *et al.*, 2022). Numerous studies have been performed to investigate the relation between dietary factors and prostate cancer, however occasionally opposed data were obtained. Dairy products, red meat, and processed meat consumption were reported to be linked with the increased prostate cancer risk. On other side, green tea soybeans, and tomatoes might diminish the risk of prostate cancer incidence (Sun *et al.*, 2021). Moreover, further studies are required to investigate the relation between specific dietary supplements and prostate cancer risk. Also, future studies should light on the benefits of nutritional epidemiology and the prostate cancer prevention.

2. Available screening methods (e.g., PSA test, DRE Exercise for prostate cancer)

In 2018, concerning prostate-specific antigen (PSA) screening update, the U.S. Preventive Services Task Force recommended periodic PSA-based screening for PCa for men aged 55–69 years (Force *et al.*, 2018).

Meanwhile, some USA authorities council annual screening beginning at age 40 years for increased PCa incidence and mortality men groups as Black men (Nyame *et al.*, 2021). In December 2022, the recommendations stated by EU Council drove their member states to assess the effectiveness and feasibility of PSA testing implementation in combination with magnetic resonance imaging (MRI) scanning as a follow-up test in organized screening programs for PCa (Bergengren *et al.*, 2023). In summary, screening for PCa is acquiring acceptance and is anticipated to increase in the future.

3. Benefits of early detection

Meanwhile, prostate cancer is ideal disease for early detection. In general the neoplasm is considerably slow growing; permitting an adequate lead time for cancer to be recognized prior to it becomes incurable. The benefits are primarily constituted improving in prognosis and decreasing cost of treatment (Littrup *et al.*, 1993).

Methodology

A cross-sectional study was carried on 306 males of whom the majority was between 50–59 years old (41.5%) from January 2025 to March 2025. Self-administered questionnaire was employed to gather data. Bivariate data were analyzed statistically via chi-squared using SPSS software package version 26. A threshold p value of < 0.05 was set as the marker for statistical significance.

Study limitations comprise the use of a self-administered questionnaire that could drive to response alignment in which some participants may provide inaccurate responses.

Results

A total of 306 males completed the questionnaire, of whom the majority were between 50–59 years old (41.5%). Around 63.4% of participants were working, and 32% were retired. The high-rated urban participants constitute 46.4%, followed by low-rated urban



(31.7%) and then rural region (21.9%). Most of participants are of university education level (34.3%) while the least groups are the non-educated and the intermediate education as 10.5% and 8.8% respectively table (1).

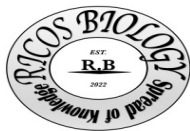
Table 1: Demographic features of participants

Feature	Number	Percentage %
Age		
40-49	78	25.5
50-59	127	41.5
60-69	86	28.1
70-79	12	3.9
≥80	3	1.0
Region		
High-rated urban	142	46.4
Low-rated urban	97	31.7
Rural	67	21.9
Education		
Non- educated	32	10.5
Preparatory school	44	14.4
Intermediate school	27	8.8
Secondary school	61	19.9
University	105	34.3
Higher level	37	12.1
Occupation		
Working	194	63.4
Not working	14	4.6
Retired	98	32.0

Around twenty percent (20.9%) of participants or their relatives have suffered from a prostate condition. The prostatic enlargement was the most condition reported among the concerned participants (50.0%). On other side, 4.6% had prostate cancer. Family history of prostate conditions was reported in 14.7% table 2.

Table 2: Personal and family history of prostate conditions

Question	Number	Percentage %
Have you or any of your family members had suffer from prostate conditions?		
Yes, I had	19	6.2
Yes, my family member	45	14.7
No	242	79.1
Who is the affected family member?		
Brother	9	20.0
Father	31	68.8
Other	5	11.2
What was the condition?		
Prostate enlargement	32	50.0
Prostate inflammation	20	45.4
Prostate cancer	3	4.6



According to table (3), 47.4% of participants had gained their information about prostate cancer mainly through social media and internet, followed by healthcare providers (25.8%), the television and radio media (18.3%), and finally heard from friends or family member (8.5%).

Table 3: Source of information about prostate cancer

Question	Number	Percentage %
How participants get their information?		
Healthcare providers	79	25.8
Social media and internet	145	47.4
The television and radio media	56	18.3
Friends / family member	26	8.5

Extracting from table (4), the most well-known risk factors among the participants were age over 50 years (63.1%) and family history (44.1%). Moreover, fewer participants were aware of smoking (20.3%), obesity (17.6%), and alcohol (9.8%). The dietary behavior constituted high fat diet (21.9%) and meat consuming (12.7%). On the other side, 67.6% of participants believed that physical activity is the prime protective factor versus prostate cancer, persuaded by a high intake of fruits and vegetables (42.8%), then a low-fat diet (24.5%) and vitamin D/E supplementation (14.5%).

Table 4: Risk factors of prostate cancer

Question	Number	Percentage %
Have you know about the risk factors related to possibility of prostate cancer occurrence		
Age over 50 years	193	63.1
Family history	135	44.1
Smoking	62	20.3
Alcohol	30	9.8
Obesity	54	17.6
High fat diet	67	21.9
Meat consuming	39	12.7

Table 5: Protective factors against prostate cancer

Question	Number	Percentage %
Have you know about the protective factors against prostate cancer		
Physical activity	207	67.6
High intake of fruits and vegetables	131	42.8
Low-fat diet	75	24.5
Vitamin D/E	44	14.4

Majority of the participants don't hear about PSA (86.3%). More than half of the other participants sector hears about PSA from social media (52.4%), followed by internet (19.0%), then healthcare providers (17.2%), and family or friends (11.9%) as shown in Table 6.



Table 6: Knowledge about PSA and source of knowledge

Question	Number	Percentage %
Do you hear about PSA test		
Yes	42	13.7%
No	264	86.3%
Knowledge source about PSA		
Friends/family member	5	11.9%
Social media	22	52.4%
Internet	8	19.0%
Healthcare provider	7	17.2%

Furthermore, according to data in table (7); 94.4% of the participants had an inadequate level of knowledge about both the PSA test and prostate cancer 96.4% had a negative attitude towards them. The majority of sample stated that they had never been told about the PSA test or its benefits by their physicians (92.5% and 93.5%, respectively). Only 15 participants (4.9%) had done the PSA test before.

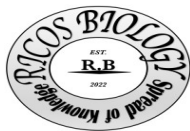
Table 7: Knowledge and attitudes toward prostate cancer and PSA test

	Number	Percentage %
Level of knowledge		
Inadequate	289	94.4%
Adequate	17	5.6%
Attitude		
Negative	295	96.4%
Positive	11	3.6%
Have you ever been told by your doctor about PSA?		
Yes	23	7.5%
No	283	92.5%
Have you ever been told by your doctor about advantage of PSA?		
Yes	20	6.5%
No	286	93.5%
Have you had PSA before?		
Yes	15	4.9%
No	291	95.1%

The participants' age group (50-59 years), high-rated urban as well as the university and higher education levels had a statistically significant effect on the knowledge level of prostate cancer and the PSA test compared to other groups ($P < 0.001$) as given in table (8).

Discussion

Prostate cancer is frequently asymptomatic and ordinarily recognized in the geriatric population. Majority of cases are found incidentally in clinical statuses. The number of clinically diagnosed prostate cancer cases is expected to elevate with the rapid development



of healthcare and screening progress (Hilscher *et al.*, 2022). In spite of early screening is known to influence treatment outcomes significantly, it demands high levels of awareness among the population and a positive attitude across it (Atulomah *et al.*, 2010).

Table 8: The relationship between demographic features and level of knowledge

Feature	Level of knowledge			
	Inadequate (n≈289)		Adequate (n≈17)	
	Number	Percentage %	Number	Percentage %
Age				
40-49	75	26.0	3	17.6
50-59	121	41.9	6	35.4
60-69	83	28.7	3	17.6
70-79	9	3.1	3	17.6
≥80	1	0.3	2	11.8
Region				
High-rated urban	133	46.0	9	52.9
Low-rated urban	92	31.8	5	29.4
Rural	64	22.1	3	17.6
Education				
Non- educated	32	11.0	0	0
Preparatory school	44	15.2	0	0
Intermediate school	27	9.3	0	0
Secondary school	60	20.8	1	5.9
University	100	34.7	5	29.4
Higher level	26	9.0	11	64.7
Occupation				
Working	192	66.4	2	11.8
Not working	10	3.5	4	23.5
Retired	87	30.1	11	64.7

In this study, 47.4% of participants had heard about prostate cancer through mainly social media and the internet, followed by healthcare providers (25.8%), the television and radio media (18.3%), and friends or family member (8.5%). These outcomes near results obtained by Gift *et al.* (2020) that revealed that only 33.5% of participants had heard about prostate cancer. On the other hand, the result in contrast to a study performed by Benurugo *et al.* (2020), which found that 77% of their participants had heard about prostate cancer from healthcare providers and less commonly from the internet (6%) and social media (5%). In parallel, a study performed in Ghana revealed that 40.3% of participants had heard about prostate cancer from healthcare providers (Necku *et al.*, 2019). The low levels of knowledge about prostate cancer, its risk factors, signs, and screening tests in this study may contributed to low education and general awareness due to inadequacy in the role of media as well as healthcare providers and authorities. Meanwhile, acquiring knowledge from social media has its drawbacks as not all information published on the internet is precise and adequate.

Age over 50 years (63.1%) and family history (44.1%) were the most well-known risk factors among participants, while high fat diet (21.9%) smoking (20.3%), obesity (17.6%),



meat consuming (12.7%) and alcohol (9.8%) were the least known risk factors. These findings harmonized with the results of Benurugo *et al.* (2020), who stated that family history was the most familiar risk factor among Rwandan participants. However, the results contradict Nigerian study which defined sexual activity as the most known risk factor of prostate cancer followed by age, family history, and occupation (Oladimeji *et al.*, 2010).

Concerning the protective factors; it was found that physical activity, high intake of fruits and vegetables, low-fat diets and vitamin D/E supplementation were the most familiar versus prostate cancer among study participants. Contrarily, participants in a previous study were not aware of the protective impacts of either physical activity or diet control (Benurugo *et al.*, 2020).

The current study data indicated that low percentage of participants (13.7%) hear about PSA, mostly from social media (52.4%), followed by internet (19.0%), then healthcare providers (17.2%).

These findings were consistent with other previous studies, which revealed that more than half of samples had a poor level of knowledge of both prostate cancer and the PSA test, with a negative attitude towards them (Oladimeji *et al.*, 2010 and Gift *et al.*, 2020).

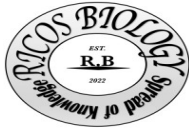
Meanwhile, the findings were in contrast of that obtained by Necku *et al.* (2019), who stated that almost of their study participants (76%) knew about the PSA screening test. Also, another opposite study performed in Italy exposed that 72.7% of participants were aware of the PSA test almost from physicians (51.1%) (Morlando *et al.*, 2017).

Notably, only 15 participants (4.9%) in the current study had done a PSA test before, which is greatly lower than what was reported by other studies in Italy, Ghana, Rwanda, and Zambia. This may be attributed to the lack of education and shortage of healthcare providers' advice (Morlando *et al.*, 2017; Necku *et al.*, 2019; Benurugo *et al.*, 2020; and Gift *et al.*, 2020).

The current study exposed that the higher education levels of the participants' had a statistically significant impact on the knowledge level of prostate cancer and the value of PSA test compared to other groups ($P < 0.001$). This outcome was on line with the finding of other study addressed participants belonged to 14 Middle East countries (90.5%), (Sayan *et al.*, 2024).

Conclusion

The study has exhibited a remarkable lack of knowledge and negative attitude about PCa, as well as its risk factors and early screening significance among the participants. Furthermore, there were insufficient screening practices in the investigation highlight the urgent require to provide men with detailed information about the advantages of PCa screening. Notably most of participants have gained their information from social media not from trustable sources. This may be attributed to an inadequacy in the role of healthcare providers to inform their patients properly about PCa. Improving and expanding healthcare initiatives lighted on elevating awareness about prostate cancer and its early detection.

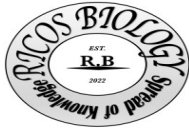


Recommendations:

Relied on the findings of the present study, suggested recommendations include i. possible implementation of educational programs in governmental and private sectors especially in employee over 50 years age to improve knowledge and commitment of prostate cancer screening. ii. Health organizations and media campaigns trials to increase the awareness about prostate cancer through TV, radio, mobile messages or social media. iii. Health care professionals especially urogenital specialists should give more time and effort to advise males about the risk of prostate cancer, its risk factors, protective factors, screening tools as well as the importance and significance of early detection. iv. Encouragement of research based organizations to conduct further studies with larger numbers of participants to raise PCa awareness.

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Food Contact Material (FCM) Migration Testing: Novel Assay for Ensuring Food Safety

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Received: 27-06-2025,

Accepted: 15-07-2025.

Published online: 23-07-2025

DOI: <https://doi.org/10.33687/ricosbiol.03.07.66>

Abstract

The safety of food is fundamental, and a pivotal aspect of this is the prospect for chemical substances to transmit from food contact materials (FCMs) into food. This approach, known as migration, can drive harmful compounds, change food quality, and institute a risk to human health. Consequently, migration testing of FCMs is a crucial component of food safety regulations globally. This article furnishes a comprehensive overview of FCM migration assay, comprising its primary principles, the analytical procedures utilized, and the global food safety standards that control it. It also discusses neoteric research trends, compliances, and, highlighting the developing nature of this critical field.

Keywords: Food Contact Materials, Food Safety, Chemical Migration, Migration Testing, Non-Intentionally Added Substances (NIAS).

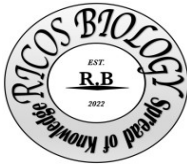
Introduction

The Concept of Migration

Food contact materials involve a broad range of materials or articles, such as packaging, kitchen utensils, and processing equipment that proposed to come into contact with food products (Muncke *et al.*, 2020). This concept, known as migration, can drive to food contamination, influencing both the quality and safety of food. The safety of FCMs is a vital issue due to the possible for chemical components to transmit from the material into the foodstuffs (Muncke *et al.*, 2021). Although, they serve necessary functions like protection and preservation, they are not inert. Migration is a physical procedure campaigned by a concentration gradient, whereby low molecular weight components, such as additives, contaminants and monomers transmit from the FCM into the food (Urbelis and Cooper, 2021).

Factors affect the extent of the migration:

- i. Material features: The chemical composition, porosity, and diffusion coefficients of the FCM.
- ii. Migrant characteristics: Concentration of the substance in the material, the molecular weight, and polarity.



- iii. Food merits: The composition of the food, particularly its acid, fat, and water content.
- iv. Environmental circumstances: Temperature, surface area of contact and, contact time.
- v. Migration testing is planned to simulate these real-world conditions under regulated laboratory settings to evaluate the safety of FCMs.

Consequently, strict regulations and standardized assessment protocols have been instituted globally to govern and diminish the migration of harmful materials (HQTS., 2025).

This review aims to construct the present knowledge on FCM migration assay, addressing its different facets and underscoring its significance in protecting public health.

Regulatory Frameworks and Migration Restrictions

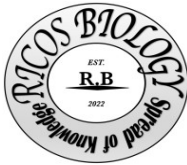
A robust legal framework is necessary to assert FCM safety. Key standards and regulations realize the needing for migration assay, involving migration restraints and testing protocols.

1. European Union (EU) has a highly developed regulatory system for FCMs (EU, 2022).
2. Regulation (EC) No 1935/2004: This "Framework Regulation" constructs general principles, revealing that FCMs must not imperil human health, induce an unacceptable alteration in food composition, or change its odor and taste (EC, 1935/2004).
3. Regulation (EU) No 10/2011: This is the particular regulation for plastic FCMs. It involves a "Union List" of authorized materials and sets both Overall Migration Limits (OML) and Specific Migration Limits (SML) (EU, No 10/2011).
4. Overall Migration Limit (OML): The total amount of non-volatile substances (NVS) migrating from the substance. The limit is typically 60 mg/kg of food or 10 mg/dm of the contact surface. This is beheld a quality, not a safety, measure.
5. Specific Migration Limit (SML): The maximum allowed amount of a specific substance that can transfer into food, relied on its toxicological risk evaluation.
6. The US regulatory system is primarily controlled by the Food and Drug Administration (FDA) under the Code of Federal Regulations (CFR) Title 21, Parts 170-199. The FDA employs different mechanisms, involving Generally Recognized as Safe (GRAS) status and Food Contact Notifications (FCNs), to assess the safety of FCMs. In similar to the EU, the FDA does not have a sole, unified OML (FDA, Title 21).

Migration Testing Methodologies

Due to the impracticality of assaying every FCM with every potential food product, standardized assaying protocols are utilized. These comprise the employ of "food simulants" and particular test circumstances (Gupta *et al.*, 2024).

1. Food Simulants (Paseiro-Cerrato *et al.*, 2019)



Food simulants are liquids planned to imitate the extractive approach of various food types. The choice of simulant relies on the proposed use of the FCM. Common food simulants realized in EU regulations involve:

Simulant A: 10% ethanol (w/v), for aqueous and acidic foods.

Simulant B: 3% acetic acid (w/v), for acidic foods with a pH below 4.5.

Simulant C: 20% ethanol (w/v), for alcoholic foods.

Simulant D2: Vegetable oil (e.g., olive oil), for fatty foods.

Simulant E: Modified Polyphenylene Oxide (MPPO), a solid material employed for dry foods.

2. Testing circumstances

Test circumstances, comprising temperature and time, are standardized to display the most intense, worst-case scenario of contact between the FCM and food. These circumstances are typically realized by the particular regulations and can scoop from short-term contact at high temperatures (e.g., for microwave use) to long-term storage at ambient temperature.

3. Analytical Methods

A vast range of analytical techniques are used to determine and quantify migrating materials. The choice of the method relies on the nature of the material being analyzed (Paseiro-Cerrato *et al.*, 2006).

4. Chromatographic Methods: backbone of the migration testing

- Gas Chromatography (GC): Often coupled with Mass Spectrometry (MS) (GC-MS) for the analysis of volatile and semi-volatile compounds.

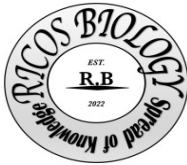
- High-Performance Liquid Chromatography (HPLC): Frequently used with detectors like Diode-Array Detection (DAD) or fluorescence detection (FLD) for non-volatile and heat-sensitive substances. HPLC coupled with MS/MS (LC-MS/MS) provides high sensitivity and selectivity, making it ideal for targeted analysis of specific migrants.

4. Spectroscopic Methods:

It is highly sensitive for the recognition and quantification of metal migration.

5. Other Techniques:

- Gravimetric analysis: The standard method for OML testing, where the residue after evaporation of the food simulant is weighed.



- Non-targeted screening: This involves advanced techniques like High-Resolution Mass Spectrometry (HRMS) to identify and quantify Non-Intentionally Added Substances (NIAS), which are substances present in the FCM but not part of the formulation (e.g., impurities, degradation products).

Emerging Challenges and Future Directions

The field of FCM migration testing is constantly evolving to address new challenges.

- Micro-plastic and Nano-plastic Migration: current research has highlighted the migration of micro- and nano- plastics from plastic FCMs, especially beneath thermal stress. This is a significant issue because of the prospect for these particles to accumulate in the body. Emerging standardized testing protocols for these particles is a prime area of present research (Geueke *et al.*, 2018).

- Non-Intentionally Added Substances (NIAS): NIAS are an evolving threat as they are often unlisted and can have unknown toxicological impacts. The move towards non-targeted screening and improved toxicological assessments is pivotal for addressing this concern (Groh M. E. *et al.*, 2018).

- Recycled Materials: The growing use of recycled plastics in FCMs presents a new challenge. Migration testing for recycled materials must assert that contaminants from the recycling process do not pose a risk to consumers (Ong *et al.*, 2020).

- Bio-based and Novel Materials: The evolving of new materials, such as bio-based polymers and active/intelligent packaging, needs the creation of novel, material-specific testing methods and regulations to ensure their safety (Seref and Cufaoglu, 2025).

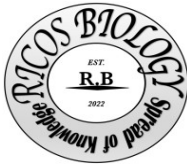
Conclusion

FCM migration testing is a fundamental tool for asserting the safety and compliance of materials that get into contact with food. By augmenting standardized protocols with advanced analytical methods, it is possible to evaluate the risk of chemical migration and guard public health. The regulatory landscape, especially in the EU and US, beholds a clear framework for compliance. However, the field continues to emerge in response to novel materials, novel contaminants like microplastics, and the requirement to screen for NIAS. Future research will be substantial in developing more comprehensive and robust techniques to keep step with innovation in the food packaging industry and assert consumer safety.

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Streptococcus suis; A Public Health Concern

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Received: 29-06-2025,

Accepted: 16-07-2025.

Published online: 23-07-2025

DOI: <https://doi.org/10.33687/ricosbiol.03.07.67>

Abstract

Pork is considered the second consumed meat worldwide, and may give rise to about twenty-five pork borne diseases. Pork could be contaminated either through infected pig or colonization in healthy reservoir population, during slaughtering by evisceration of intestinal contents, in processing and packing or even on display places in retail markets. Bacterial pathogen constitutes about 50% of pork born intoxication which may pose a zoonotic risk and threaten public health.

Streptococcus suis (*S. suis*) is a gram-positive coccal bacterial pathogen particular in pigs which can induce grave infections in human comprising meningitis, and septicaemia leading to serious complications. The pathogen can be transmitted to human via consumption or occupationally through handling and contact with contaminated pork result in sporadic or outbreak onset.

The topic was performed to investigate on *S. suis* pork born infection in human. Establishment of an efficient screening strategy and public health measures would be effective to promote understanding about the illness.

Keywords: *Streptococcus suis*, public health, *Sus scrofa domesticus*, Pork born infections.

Introduction

Domestic pigs (*Sus scrofa domesticus*) are omnivores and can consume a variety of food with proof of pig husbandry dating back to 5000 B.C., biologically, pigs are close similar to humans, thus are frequently used for human medical research. As well to pork, numerous valuable products come from swine as lard which is pig abdominal fat (Loren, 2016).

Pork is the culinary (related to kitchen) name for meat from a domestic pig. It is the most commonly consumed meat either freshly cooked or preserved, accounting for about 38% of meat production worldwide (USDA, 2024).



Pork is the most popular meat in Eastern and Southeastern Asia, and is also very prevalent in the Western world, particularly in Central Europe, Sub-Saharan Africa, the Americas and Oceania (Martins *et al.*, 2025).

Streptococcus suis (*S. suis*) is a gram-positive bacterial pathogen in pigs which can cause serious infections in human including meningitis, septicemia, and others (Dutkiewicz *et al.*, 2017).

Rapid precise diagnosis of the pathogen which implicated in the disease through advanced serological identification and molecular characterization for source tracking to define the source of outbreak (Hatrongjit *et al.*, 2020).

Looking at the previous public health concern, prevention of pork born *S. suis* contamination should take the attention through applying the proper hygienic measures in breeding places, slaughter house and processing factories besides the regarding of hygienic protective precautions of the contacts; veterinarians, raisers, workers, butchers, market vendors...etc. (Rayanakorn *et al.*, 2018).

The present topic gives lights on specific pork-borne pathogen; *S. suis* that prevalent in the whole process from slaughtered pigs through pork and pork byproducts regarding their zoonotic concern importance and public health impact. Also how to improve the management of the pathogen hazards transmitted to humans through pork consumption or pig contact.

S. suis is a facultative anaerobic Gram-positive ovoid or coccial bacterium measuring, on average, 1.0–1.5 mm, occurring in pairs, short chains, or singly. The bacterium comprises commensal part of the respiratory microbiota of swine, in particular of the nasal cavities and tonsils as well as in the reproductive and digestive tracts of pigs, with colonization rate is up to 100% (Vötsch *et al.*, 2018). It is counted a prime porcine pathogen endemic in almost all countries with a developed swine industry. In the track of evolution, some strains became virulent and invasive for pig hosts, causing meningitis, bronchopneumonia, arthritis, endocarditis, as well as septicemia and sudden death, resulting in significant economic losses worldwide (Dutkiewicz *et al.*, 2017).

Isolation of *S. suis* could be achieved by blood and CSF cultures, after 24 h or 48 h of incubation, small beta-hemolytic colonies grew on horse blood agar plates. The bacteria were catalase negative and highly susceptible to penicillin. *S. suis* virulent strains cells are characterized by a polysaccharide capsule showing a various antigenicity, resulting in serologically classified into 35 serotypes; serotypes 1–34 and serotype 1/2 which react with both serotypes 1 and 2 antisera. Otherwise, PCR and modern molecular techniques have improved the rate of detection and discrimination of *S. suis*, as the 16S rRNA gene sequencing technique is a useful and definitive. *S. suis* strains have been genotyped into more than 700 sequence types (STs) (Hatrongjit *et al.*, 2020).



Kerdsin *et al.* (2012) developed an expanded multiplex PCR assay capable of identifying all *S. suis* serotypes using four reactions. The serotypes were diminished in number to 33 because serotypes 32 and 34 were re-identified as *S. orisratti*. More recently, they were proposed to remove serotypes 20, 22, 26 and 33 from the *S. suis* taxon. Hence, it is presently considered that there are 29 true *S. suis* serotypes. This technique seemed to be beneficial in identifying the strains which lack capsule and failed to be typed by capsular agglutination test (Kerdsin *et al.*, 2014).

It is believed that *S. suis* contaminates pig carcasses subsequently pork and its products through slaughtering process, Guntala *et al.* (2024) reported the existence of *S. suis* in pork byproducts collected from abattoirs and wet/retail markets in Thailand, and found high contamination rate with *S. suis* serotype 2 in internal organ samples.

Asian countries; where poor hygienic, high intensity swine raising is common, the direct handling with infected pigs or abattoir carcasses, as well as popular cultural habits; ingestion of undercooked pork meat and pork blood as traditional drink were identified as risk factors for human *S. suis* infection (Okello *et al.*, 2015). On the other hand, *S. suis* is mediated a particular occupational pathogen that can be transferred from pigs to humans, this is hazard for butchers and abattoir workers, meat processing workers, people who transport pork, meat inspectors, and veterinary practitioners, particularly individuals have skin cuts or abrasions who handle raw pork without gloves or have close contact with infected pigs (Liu *et al.*, 2025).

The risk concern not limited to clinically diseased pig but scoped the healthy carrier or asymptomatic pigs which are important not only regarding the spread of *S. suis* in herds, but also as source of infection for humans. Most isolates from diseased pigs restricted to definite serotypes including serotypes 2, 3, 7 and 9, while in humans, the majority of clinical cases are linked with serotypes 2 and 14 however, serotypes 4, 5, 9, 16, 21, 24 and 31 have also been recorded (Meekhanon *et al.*, 2017).

Although, serotype 2 was approved as the master cause of human infections, whereas, serotype 9 is much more common in Spain, *S. suis* serotype 5 seems to be a concern in the human cases reported in 5 cases in Japan (Taniyama *et al.*, 2016). Besides sporadic cases recorded in Thailand (Kerdsin *et al.*, 2022), Sweden (Gustavsson and Rasmussen, 2014), Poland (Bojarska *et al.*, 2016), and US (Gomez *et al.*, 2014). All cases comprised pig farmers, pork shop employees or raw pork feeders.

Public health impact of *S. suis*

S. suis is supposed an emerging zoonotic agent which can transmitted to humans causing meningitis and streptococcal toxic shock-like syndrome (STSLs). In contrast to swine, humans seem to be rarely colonized by *S. suis*, therefore, human carrier rates reported to be approximately 5% on average worldwide (Okura *et al.*, 2019). Meningitis remained the most common presentation of infection in both Asia and European countries (84.6% and



75.2%, respectively), followed by sepsis (15.4% and 18.6%, respectively), which had a higher mortality rate. Other clinical presentations included enteritis, arthritis, endocarditis, pneumonia, spondylodiscitis, endophthalmitis, uveitis and peritonitis. Deafness was distinct sequelae (50.5% in Europe and 51.9% in Asia) after recovery from *S. suis* infection, especially in patients with meningitis (Haas *et al.*, 2018).

The first case of human infection with *S. suis* was reported in Denmark in 1968 (Arends and Zanen 1988), and since then, this infection has been increasingly recorded in many countries. The emergence of *S. suis* as a human pathogen was mostly clarified by the major outbreak of drastic toxic shock illness that caused high morbidity and mortality referred to infection with *S. suis* serotype 2 in Sichuan province, China, in 2005 and many patients have died and now become a great public regard worldwide (Yu *et al.*, 2006).

Shi *et al.* (2016) reported 10 recurrent cases of human *S. suis* infections during 2008–2015 in southern China. Most of the hospitalized patients were male workers in close contact with pigs, pork products, or both. These patients typically displayed clinical signs of meningitis, including headache, vomiting, fever and coma. Microbial and molecular check confirmed that these clinical isolates were *S. suis* serotype 2.

Thailand had the second top number of mentioned public health cases, regarding for 11% of all reported cases worldwide. Data proposed a high incidence rate (6.2/100,000) of *S. suis* infection in the general population in 2010, primarily associated to consumption of raw pork products (Takeuchi *et al.*, 2012). Maneerat *et al.* (2013) assayed the genetic linkage between *S. suis* serotype 2 isolates from pigs and humans through the 2007 infection outbreak in Thailand. A strong link between virulence gene profiles, assuring *S. suis* transmission from pigs to humans.

Mai *et al.* (2008) tested 450 cerebrospinal fluid aspirates of patients with suspected bacterial meningitis in southern Vietnam using qPCR. *S. suis* was the most common pathogen and recovered in 151 (33.6%) of the cases. Fifty (33.1%) of these 151 patients were reported a confirmed exposition to pigs or pork. Mortality was minimal (2.6%; 4 of 151 patients died), but mild to intense hearing loss occurred in 93 (66.4%) of 140 patients. Ninety-one of 92 *S. suis* isolated strains had serotype 2.

The first case of human confirmed *S. suis* infection in Korea, represented by an 81-year-old Korean woman had arthralgia of both knees, and neck stiffness was admitted to hospital in southern region of Korea where abundant pig farms were present around her house, and pork is the prime type of meat in Korea, and housewives often come in touch with raw pork during cooking (Kim *et al.*, 2011). A recent outbreak of *S. suis* infection in humans resulted in three confirmed cases. Three confirmed patients had some form of contact with pig history. The patients were recognized with subdural empyema, septicemia, and infectious spondylitis. *S. suis* was recovered from their blood (Kim *et al.*, 2024).



Till 2016 – 2017, there has not been any case determined from Malaysia or Indonesia rather because of the restricted pig breeding due to cultural and religious purposes. Two multiplex PCR confirmed *S. suis* cases from Malaysia were reported. The first patient was a feverish, reduced hearing, 41-year-old man who reared four pigs at home and had daily contact with them. The second patient was a 44-year-old butcher in local market handling pork and had harmed his thumb while slaughtering a pig two days before starting of fever, headache and vomiting (Rajahram *et al.*, 2017).

In contrast to Asian countries, human *S. suis* infection is mainly deemed a swine-related occupational disease in Western countries. Infection average in the general and in-risk population are little known because *S. suis* infection is not a notifiable disease. The Netherlands recorded the most *S. suis* infections in the West, and recently set *S. suis* among its top ten primacy zoonotic pathogens as the annual incidence rate of 0.002 per 100,000 persons at risk, therefore raised awareness and disease observation is ensured (Dame-Korevaar *et al.*, 2025).

Also, there were some individual cases have been recorded in other European countries; a case of a butcher with supposed meningitis, worked in pork processing plant in Poland and had a medical history of injury during the pork processing (Zalas-Wiecek *et al.*, 2013). Another sole case was reported in Portugal a 48-year-old butcher with meningitis and bilateral hearing loss, who had suffered from a finger cutting while pork meat preparing (Sena Esteves *et al.*, 2017).

Auger *et al.* (2016) mentioned that the *S. suis* Serotype 2 isolates obtained from human cases in Canada and USA; “the two countries that together are the second most important swine producers worldwide after China” were less virulent than the Eurasian strains. On the contrary the seventeen human *S. suis* strains recovered in Argentina (16 serotype 2 strains and a serotype 5 strain) as well as 14 isolates from pigs were analyzed. All human serotype 2 strains and most swine isolates were typed as sequence type 1 (ST1), a genotype typical of virulent Eurasian ST1 strains.

Data from Africa were scarce until the recent report of 15 cases with severe hearing troubles and reported constant contact with pork products in Togo (Tall *et al.*, 2016). Other report of 2 *S. suis* meningitis cases in Antananarivo, Madagascar presented a 24-year-old man worked in a swine slaughter house and suffered from fever, headache, and unilateral sixth nerve palsy in 2015, besides a 60-year-old febrile woman frequently cooked pork meat in 2016, (Raberahona *et al.*, 2018). These reports highlighted the up growth of this pathogen in Africa and boosted the need for precise epidemiological and surveillance studies of *S. suis* infections and for educating clinicians and risk groups in non-endemic countries (Prince-David *et al.*, 2016).

The bad consequence of *S. suis* infection in human not restricted for meningitis and permanent deafness but may put out to another sequels, such as endocarditis. Three male cases aged 27–53 years in Thailand, were reported between January 2010 and December



2011. All in a common risk factor for eating undercooked pork, and the molecular analysis was positive for *S. suis* serotype 2 (Roodsant *et al.*, 2021). As well, Yanase *et al.* (2018) pointed out the first human case who, its magnetic resonance imaging (MRI) revealed pyogenic ventriculitis in addition to meningitis. A 45-year-old male who handled raw pork and *S. suis* serotype 2 was confirmed.

Although the natural niche for *S. suis* is considered to be the pig, a wide range of host species found to be affected by this pathogen. Such issue was reported shortly in a notification of a 5-month-old crossbred beef steer died after exhibiting astasia in Japan. A postmortem examination revealed endocarditis and numerous renal hemorrhages. Gram-positive cocci were isolated and identified via biochemical tests and 16S rRNA gene sequence analysis as *S. suis* (Komatsu *et al.*, 2018).

Before that, in USA, sixteen isolates of Gram-positive, coccoid bacteria were recovered from clinical cases of varied conditions in cattle and identified as *S. suis* using 16S rRNA gene sequencing. None of the isolates could be assigned to any of the known *S. suis* capsular types (Okwumabua *et al.*, 2017).

Furthermore, *S. suis* was isolated from 2 lambs with a history of lameness. Identity of *S. suis* was confirmed by PCR and 16S rRNA gene sequencing. One isolate was non-typable by serotyping and non-encapsulated, while the other isolate was serotype 33. This will give attention for future probability of increasing the scope infection to livestock population and subsequently their meat (Muckle *et al.*, 2014).

It is critical to remember that inner-ear impairment can occur frequently in *S. suis* meningitis surviving patient, so proper and rapid diagnosis concerning pig contact or improper pork consumption besides early antimicrobial treatment are the most significant factors in diminishing the bad functional dysfunction (Li *et al.*, 2024).

Evolution of antimicrobial resistance in *S. suis* rises the risk for therapeutic fail in both animals and humans. Yu *et al.* (2018) discussed the synergism of augmentation therapy against multi-resistant *S. suis* isolates from swine. The blend of ampicillin plus apramycin and tiamulin plus spectinomycin exhibited the greatest synergism and may be potential strategies for treatment of multi-resistant *S. suis*.

In the absence of efficient human vaccines to combat *S. suis* and noticed rise of antibiotic resistance of *S. suis*, the seeking for new alternative antimicrobial strategies is of particular regard. Treatment with Nisin, 'the only approved bacteriocin for food preservation' results in bacterial lysis due to cell membrane breakdown. Significant synergistic effects of nisin were observed in combination with antibiotics presently used to treat *S. suis* infections (Zhu *et al.*, 2021).

Continuation of research on production of an effective and safe vaccine is important. Positive examples of such studies are the results obtained recently by Chinese scientists.



Jiang *et al.* (2016) identified a natural low-virulence *S. suis* type 5 strain XS045 as a live vaccine candidate, and demonstrated its safety and effectiveness by providing cross-protection against challenges by type 2 and type 9 *S. suis* strains. In another study, Wang *et al.* (2017) detected significant genomic differences between the avirulent *S. suis* strain 05HAS68 and the highly virulent strain 05ZYH33. Piglets vaccinated with the avirulent strain were fully protected from challenge infection with the virulent strain.

Li *et al.*, (2021) prepared vaccine employing *S. suis* ghosts and its protective efficacy was assessed in mice. Serums were gathered from the groups and indirect ELISA results revealed that antibody titer of mice from group *S. suis* 2 ghosts and group *S. suis* 9 ghosts were significantly higher than blank group, but were near to the conventional inactivated vaccine group SS2. So, *S. suis* ghosts as candidate vaccine strategy displayed an excellent immunogenicity and give protection versus *S. suis* challenge in mice model.

Until the human vaccines validated, the principle of reduce human risk based on the prevention of pig population pathogen colonization. Currently, both commercial vaccines and inactivated autogenous vaccine are used. Although the use of commercial vaccines is more suitable, they often supply protection only versus the most important capsular type 2 of *S. suis*, but not against a lot of other capsular types that can also arouse the disease. In contrast, the use of autogenous vaccines is upsetting because each new batch needs experimental screening on animals, but in the end, they give better protection and block the expansion of the disease in herds during outbreaks of *S. suis* infection. Nevertheless, a polyvalent commercial vaccine that would conserve pigs from infection with all *S. suis* types is strongly desired (Jeffery *et al.*, 2024).

Different approaches are the injection of piglets at birth with long-acting penicillin, such an injection may prevent the disease, but this way should be used with caution to avoid the risk of antibiotic-resistant strains up growth. *S. suis* type 2 has been shown to be susceptible to current used disinfectants, soaps and cleansers, such as 5% bleach at 1:800 dilution. Eradication of disease by slaughter, followed by disinfection and repopulation, may be effective in controlling the disease but may not be economically favorable (Lv *et al.*, 2025).

Conclusion

Although *S. suis* infection is prevalent, low number of cases were recorded and this is attributed to under diagnosis and unawareness of the illness. The organism is often misrecognized by clinicians leading to delay or inadequate therapy. It is substantial that patients with proposed *S. suis* clinical signs with prospecting risk factors should receive suitable care while waiting for laboratory assertion in spite of negative bacterial culture either due to misrecognizing or former antibiotic application. Evolving a screening scheme would be beneficial to facilitate the remedy decision. Once a clear clinical picture is recognized, the diagnosis should be easier. The instant empirical treatment with penicillin or antimicrobial



that the pathogen is sensitive to before evolvement of complications especially deafness would be substantial in prohibiting long term mortality and morbidity.

In a miss of vaccination, the best mitigation measure is to restrict the illness transmission. Public health interventions involving a food safety campaign would be efficient to promote understanding about the illness particularly in settings where there is a strong link between raw pork consumption and conventional culture.

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