**Securing the Supply Chain from the Dangers Posed by STEC: An Insight into the Potential Benefits of this Research Material for ALS Global and the Food Industry**

The research underscores the threat of Shiga toxin-producing *Escherichia* *coli* (STEC) to the food industry and public health and the pivotal role of ALS Global, a leading testing services provider, in mitigating this threat. Known for causing severe diseases in vulnerable populations like children and the elderly, STEC is transmitted through contaminated food and water. The study reveals a correlation between socioeconomic status (SES) and STEC incidence, with higher severe cases in disadvantaged populations. This data empowers ALS to educate clients and influence consumer food choices, positioning them as key players in the fight against STEC.

The research highlights the complexity of STEC classification and its financial risks for ALS clients, especially those dealing with ready-to-eat (RTE) items and presents an opportunity for improvement. Misclassification may lead to recalls (Food Standards Agency, 2020), but by prioritising toxin genotypes over traditional serotyping, ALS can avoid such pitfalls. The research also cautions against the indiscriminate use of antibiotics in treating STEC infections and proposes newer, more efficient testing methods. These insights allow ALS to develop cost-effective testing protocols, potentially saving financial losses. By incorporating these insights, ALS can position itself as a global leader, offering personalised, high-quality services in the food industry.

**Unveiling STEC: Significance in the Food Industry, Exploring Testing Methods, and Challenges**

**Abstract**

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Figure 1. Graph showing the yearly incidence of STEC cases per 100,000 population in England and Wales (GOV.UK, 2023, Figure 1).

Shiga toxin-producing *Escherichia* *coli* (STEC) is a significant public health threat due to its diverse serotypes and varying virulence. Traditional O157: H7 and non-O157 classifications overlook the severity linked to Shiga toxins, underscoring the urgent need for accurate detection methods. The 2011 *E.coli* O104: H4 outbreak further stresses the importance of toxin genotyping. This article explores STEC's complexities, emphasising its impact on the food industry, testing challenges, and the need for accurate methods. Transmission occurs from eating food items infected with STEC, with vulnerable populations at higher risk. Understanding STEC's intestinal pathogenicity is vital, highlighting potential vaccine development. Labs use varied techniques for detection and challenges, including antimicrobial resistance and complicated management. Socioeconomic status influences STEC incidence, emphasising the need for targeted interventions and the food industry's responsibility.

**Introduction**

STEC encompasses a diverse group of zoonotic pathogens characterised by genes encoding Shiga toxins. These toxins, specifically Shiga toxin 1 (Stx1) and Shiga toxin 2 (Stx2), play a crucial role in the severity of diseases caused by STEC, including bloody diarrhoea and haemolytic uremic syndrome (HUS) (figure 2) (Delannoy *et al*., 2016). The classification of STEC strains involves serotyping based on O and H antigens, with two main groups identified as O157:H7 and non-O157. However, the virulence factors, particularly the production of Shiga toxins, determine the severity and urgency of managing STEC infections, as they can lead to life-threatening conditions (Delannoy *et al*., 2016).

The global significance of understanding the toxin genotype, rather than relying solely on the *E.coli* serotype, was underscored by the 2011 outbreak caused by *E*.*coli* O104:H4 producing Stx2. This outbreak, a stark reminder of the global impact of STEC, resulted in over 4000 infections across 16 countries, with 908 cases of HUS and 50 fatalities. It highlights the urgent need for a comprehensive understanding and effective management of STEC, particularly in the food industry (Freedman, Nicole and Tarr, 2023).

**Mode of Transmission, Risk Factors, and Toxicity Level**

STEC transmission to humans occurs through food and water consumption and exposure to animals and faeces that have been contaminated with STEC. Transmission of STEC from one infected person to another is also possible, with children and the elderly being more susceptible to illness and HUS. Low contamination levels in food can lead to illness, and the low infection dosage supports the idea that person-to-person contact further propagates STEC diseases (Adams *et al*., 2019).

**Mechanism of STEC Attachment and Pathogenicity in the Intestinal Environment**

STEC affects the intestinal epithelium upon ingestion, secreting effector proteins that mimic host ligands and receptors for adhesion. This adhesion mechanism induces inflammatory responses and the development of lesions in the colon's inner wall. The potential of these bacterial effector proteins as vaccine candidates offers a glimmer of hope for the future of STEC management (Hwang *et al*., 2021).

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Figure 2. Clinical presentation and the progression of STEC infection (Yun *et al*., 2023, p. 2, Figure 1).

**Laboratory Testing of STEC Infections**

Laboratories employ various techniques for STEC detection, including strain enrichment, molecular detection, and isolation. Strain enrichment involves the growth of bacteria in specialised media, and chromogenic media enhances selectivity. Enzyme immunoassays using monoclonal antibodies aid in identifying specific toxins, while PCR assays are favoured for their sensitivity and specificity (Parsons *et al*., 2016).

DNA amplification using Janus particles and rotational diffusometry provides results rapidly within 20–40 minutes (Figure 3A). Electrochemical DNA-based sensors offer simultaneous, amplified-free detection of stx1 and stx2 genes with impressive sensitivity (0.01 nM for stx1 and 0.025 nM for stx2) (Figure 3B), contrasting with traditional PCR methods, which require amplification and electrophoresis (Yun *et al*., 2023).

A close-up of several different types of electronics

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Figure 3. Detection technology for Shiga toxin genome. **A** Janus microbeads are functionalised and introduced into the solution. As nucleic acid amplification occurs, the solution viscosity increases due to the added genetic material. The rotational diffusivity of the microbeads is then measured by capturing images, mainly focusing on blinking signals. **B** Enables the identification of stx1 and stx2 genes using DNA hybridisation probes without the need for amplification. The sensor quantifies the current signal from DNA samples containing spiked stx1 and stx2 genes, employing DNA hybridisation probes affixed to the electrode surface. (Yun *et al*., 2023, p. 6, Figure 2).

**Challenges**

Detecting STEC in food enrichments is challenging due to low pathogen levels and competition with other bacteria. The different behaviour of STEC O157 and non-O157 on selective media adds complexity(Hudson, 2017). Antibiotic overuse in agricultural regions leads to multidrug resistance, promoting increased toxin production and complicating STEC management. Treatment methods involve antibody therapy and DNA-based vaccinations(Hwang *et al*., 2021).

**Significance in the Food Industry**

**Cost of Testing.**

The cost of testing, particularly false positives from molecular methods, poses a challenge. A fast and accurate testing method is essential to prevent undue costs and ensure food safety. The 2011 outbreak in Germany, where cucumber was erroneously identified as the source, resulted in a significant economic loss of €812 million for European fruit and vegetable producers (Delannoy *et al*., 2016).

**Social Economic Status (SES)**

There is a lower incidence of milder cases of STEC in populations with lower SES, attributed to lower educational levels of STEC awareness. This leads to more severe cases in populations with lower SES. Understanding these socioeconomic factors is crucial for implementing effective public health strategies(Adams *et al*., 2019).

**Conclusion**

STEC poses a significant threat to public health, with its diverse strains and potential for severe diseases. Understanding the complexities of STEC classification, transmission, pathogenicity, testing methods, and its significance in the food industry is imperative for effective prevention, management, and food safety. Ongoing research and collaboration between the scientific community, public health agencies, and the food industry are essential to address the challenges posed by STEC and protect the well-being of individuals and communities worldwide.

**References**

1. Adams, N.L., Byrne, L., Rose, T.C., Adak, G.K., Jenkins, C., Charlett, A., Violato, M., O’Brien, S.J., Whitehead, M.M., Barr, B., Taylor-Robinson, D.C. and Hawker, J.I. (2019). Influence of socio-economic status on Shiga toxin-producing *Escherichia* *coli* (STEC) infection incidence, risk factors and clinical features. *Epidemiology and Infection*, 147. doi:https://doi.org/10.1017/s0950268819000864.
2. Delannoy, S., Chaves, B.D., Ison, S.A., Webb, H.E., Beutin, L., Delaval, J., Billet, I. and Fach, P. (2016). Revisiting the STEC Testing Approach: Using espK and espV to Make Enterohemorrhagic *Escherichia* *coli* (EHEC) Detection More Reliable in Beef. *Frontiers in Microbiology*, [online] 7. doi:https://doi.org/10.3389/fmicb.2016.00001.
3. Food Standards Agency. (2020). Protecting consumers from infection with Shiga toxin-producing *E.coli* (STEC). [online] Available at: https://www.food.gov.uk/business-guidance/protecting-consumers-from-infection-with-shiga-toxin-producing-e*coli*-stec [Accessed 26 Feb. 2024].
4. Freedman, S.B., Nicole and Tarr, P.I. (2023). Shiga Toxin–Producing *Escherichia* *coli* and the Hemolytic–Uremic Syndrome. The New England Journal of Medicine, 389(15), pp.1402–1414. doi:https://doi.org/10.1056/nejmra2108739.
5. Hudson, J.A. (2017) On the perils of detecting foodborne pathogenic bacteria in foods. New Food 20: 23-26.
6. Hwang, S., Chelliah, R., Kang, J.E., Rubab, M., Banan-MwineDaliri, E., Elahi, F. and Oh, D.-H. (2021). Role of Recent Therapeutic Applications and the Infection Strategies of Shiga Toxin-Producing *Escherichia* *coli*. *Frontiers in Cellular and Infection Microbiology*, 11. doi:https://doi.org/10.3389/fcimb.2021.614963.
7. Parsons, B.D., Zelyas, N., Berenger, B.M. and Chui, L. (2016). Detection, Characterization, and Typing of Shiga Toxin-Producing *Escherichia* *coli*. *Frontiers in Microbiology*, [online] 7. doi:https://doi.org/10.3389/fmicb.2016.00478.
8. Yun, Y.-S., Park, D.-Y., Oh, I., Shin, W.-R., Ahn, G., Ahn, J.-Y. and Kim, Y.-H. (2023). Pathogenic Factors and Recent Study on the Rapid Detection of Shiga Toxin-Producing *Escherichia* *coli* (STEC). *Molecular Biotechnology*. doi:https://doi.org/10.1007/s12033-023-00985-8.