Exploring food manufacturing, hospitality and catering industry perceptions of the application of intelligent technology to determine handwashing compliance

Dr Ellen Evans, Dr Claire Haven-Tang & Dr Ambikesh Jayal

ZERO2FIVE Food Industry Centre, Cardiff School of Sport & Health Sciences

Welsh Centre for Tourism Research, Cardiff School of Management

Cardiff School of Technologies

chaven-tang@cardiffmet.ac.uk

Key words: hand-hygiene, artificial intelligence, machine learning, food safety

Introduction

Handwashing is the single most effective way to prevent the spread of diseases and is essential in hospitality, catering and food manufacturing businesses to ensure food safety and reduce the risk of foodborne illness (Walker *et al.*, 2003; Todd *et al*., 2010). Yet, inadequate food-handler hand-hygiene has been frequently cited as a contributory factor in foodborne illness (Todd *et al.*, 2007; Kadariya *et al.*, 2014). Video-observation studies of handwashing practices in food manufacturing businesses conducted by the ZERO2FIVE Food Industry Centre (FIC) found that whilst valuable for industry, this frequent and structured observation is extremely time-consuming and costly to conduct (Evans *et al.*, 2019; Evans & Redmond, 2019; Evans *et al.*, 2020). Furthermore, there are lost opportunities for targeted interventions, as when outcomes are presented to food manufacturing businesses, data is outdated and not indicative of current performance (Evans *et al*., 2021). Consequently, there is a need for real-time data regarding handwashing compliance of food-handlers. This paper outlines a multidisciplinary collaboration between FIC (Cardiff School of Sport and Health Science), Welsh Centre for Tourism Research (WCTR) (Cardiff School of Management) and Cardiff School of Technologies, funded by the Global Academies R&I Development Fund on the potential application of Artificial Intelligence (AI) and Machine Learning (ML) for assessing hand hygiene standards in food manufacturing, hospitality and catering environments.

Background

Globally, foodborne diseases are a major public health concern (Kadariya *et al.*, 2014); with improper food handling practices contributing to a high number of foodborne disease outbreaks (Clayton *et al.*, 2002; Lues & van Tonder, 2007). Whilst collecting data on food-handler handwashing knowledge and attitudes is informative, such data is not indicative of actual behaviour (Abbot et al., 2007). Hence, despite the fact that food-handlers may demonstrate food safety awareness, this knowledge does not necessarily translate into actual safe behaviour (Rossi *et al.*, 2016). Indeed, self-reported practices are subject to 'social desirability biases', whereby good practices are over-reported and bad practices are under-reported. Consequently, Powell (2010) asserts that observational data are superior to survey data and the handwashing practices of food-handlers should be observed to determine compliance with recommended protocols. However, researcher presence in direct observations can cause reactivity bias (Harris & Lahey, 1982), such as the Hawthorne Effect, whereby behaviour may be altered to accommodate the observer present. Recent FIC research (Evans *et al.*, 2019; Evans *et al*., 2021) established that whilst several food manufacturing businesses have CCTV cameras in handwashing areas; they do not have time to review this footage and the FIC review of this footage revealed that the vast majority of food-handlers do wash their hands, but their attempts are not compliant with industry protocols.

AI has increased in popularity as more businesses seek to improve efficiency of transactions through automated processes (Nam *et al.*, 2020); whilst as a subset of AI, ML has been used to enhance

revenue management, operational analytics, customer experiences and destination image selection (Deng & Li, 2018; Ganga *et al*., 2018). Indeed, Nam *et al* (2020) suggests that previous studies of AI, particularly within the hospitality industry can be split into three broad categories: robotics, human resource issues and theoretical perspectives of the impact of technology adoption and implementation. However, whilst there appears to be much uncertainty about the implications of AI, especially in relation to the replacement of people with robots; there is little research on the use of AI to improve processes which could protect consumers, such as food-handlers' compliance with recommended handwashing protocol.

Research Approach

The purpose of this study was to explore the perceptions of industry regarding the unproven concept of developing AI and ML technology to address the need for real-time data on the handwashing compliance of food-handlers. This exploratory phase was important to explore potential benefits, acceptability, practicalities and concerns regarding the application of intelligent technology in food environments. Eleven semi-structured interviews were conducted with food manufacturing and hospitality/catering businesses, already known to the FIC and WCTR; following ethical approval from the Cardiff School of Sport and Health Sciences research and ethics committee (Ethics reference number: Sta-2549). In studies of this nature, Becker (cited Baker & Edwards, n.d) purports one interview to be sufficient; hence eleven interviews were deemed to be adequate for this exploratory study within the context of the wider project. Due to Covid-19 restrictions, all interviews were conducted by members of the research team via Microsoft® Teams video call or telephone. Interview audio files were transcribed and then analyzed using a thematic analysis approach (Braun *et al.*, 2018) in NVivo 12 to capture key themes.

Preliminary Findings

Generally, respondents were supportive of the concept, as real-time data would accurately indicate levels of hand-hygiene compliance. Discussions regarding the potential application of the technology with a manufacturing business determined that they would not want the technology to identify individuals who are not compliant; instead, the technology would have a positive impact if it was to determine handwashing compliance rates for different shift teams to create healthy competition and enable 'reward' and 'recognition' – two things that are critical in developing a positive food safety culture in a manufacturing business (Global Food Safety Initiative, 2018). Similarly, other respondents thought that the technology could aid consistency and reinforce individual accountability for handwashing, especially in hospitality environments. Initial findings suggest that the proposed technology may be more applicable to high-care and high-risk food production compared to low-care. However, despite the heterogeneity of hospitality and catering environments, many of whom are microbusinesses (Jones & Haven-Tang, 2005; Haven-Tang & Jones, 2008; 2013), the detrimental economic consequences of any foodborne illness were felt to outweigh the cost of such technology. Application of this technology which enables a computer to classify 'compliant' handwashing attempts and give real-time data will negate the need for a researcher to observe and evaluate handwashing attempts, thus providing immediate data for businesses. Such establishments will be able to swiftly implement targeted interventions to address instances of non-compliance; thus, development of this technology could revolutionise hand-hygiene compliance, thereby reducing the risk of foodborne illness to consumers and safe guarding food safety management systems.

Ongoing research

Access to businesses from March 2020 was significantly impeded due to the COVID-19 pandemic as businesses were either closed or restricted to key-worker employees only. The COVID-19 pandemic also impacted on-campus access and the ability of the research team to video record compliant and non-compliant handwashing attempts using the World Health Organisation (n.d.) protocol and food

industry recommended practices (Taylor *et al.*, 2000; Taylor & Holah, 2000). As of March 2021, work is progressing since handwashing attempts have been video-recorded and the footage will be used to enable deep learning and machine learning approaches to automatically label the videos as *compliant* or *non-compliant*. Validation of the initial product will then be required and the research team will film further handwashing attempts to determine if the developed technology can distinguish between compliant and non-compliant handwashing attempts. Following completion of these phases, the research team will evaluate the feasibility and functionality of the developed technology within intended environments, i.e.: food manufacturing, catering and hospitality establishments.

References:

Abbot, J.M., Byrd-Bredbenner, C., Schaffner, D., Bruhn, C.M. & Blalock, L. (2007) Comparison of food safety cognitions and self-reported food-handling behaviors with observed food safety behaviors of young adults. *European Journal of Clinical Nutrition*. 63:572-9

Baker, S. E. & Edwards, R. (n.d.). *How many qualitative interviews is enough?* Accessed 26th March 2021 from: http://eprints.ncrm.ac.uk/2273/4/how_many_interviews.pdf

Braun, V., Clarke, V., Hayfield, N., & Terry, G. (2018). Thematic analysis. In P. Liamputtong (Ed.), *Handbook of Research Methods in Health Social Sciences* (pp. 1-18). Singapore: Springer Singapore.

Clayton, D. A., Griffith, C. J., Price, P. & Peters, A. C. (2002) Food-handlers' beliefs and self-reported practices. *International Journal of Environmental Health Research*. 12(1): 25–39

Deng, N. & Li, X. (2018) Feeling a destination through the 'right' photos: A machine learning model for DMOs' photo selection. *Tourism Management*. 65: 267-278

Evans, E. W. & Redmond, E. C. (2019) Video Observation of Hand-Hygiene Compliance in a Manufacturer of Ready-To-Eat Pie and Pastry Products. *International Journal of Environmental Health Research.* 29(6): 593-606.

Evans, E.W., Evatt, R.L.A, Samuel, E.J., Bunston, C., Mayho, S. & Redmond, E.C. (2019) *Utilizing Remote Covert Observation in Food Manufacturing and Processing Environments to Assess Hand Hygiene Compliance*. Poster presented at the International Association for Food Protection (IAFP) Annual Meeting on 21st-24th July, 2019 in Louisville, Kentucky, USA.

Evans, E.W., Samuel, E.J., & Redmond, E.C. (2020) A case study of food-handler hand hygiene compliance in high-care and high-risk food manufacturing environments using covert-observation. *International Journal of Environmental Health Research*. 7;1-14

Evans, E.W., Samuel, E.J., Mayho, S., Redmond, E.C., & Taylor, H.R. (2021) Feasibility of CCTV use to assess hand hygiene compliance in food manufacturing businesses. *Food Safety Management in Practice.*

Ganga, R.S., Reddy, P.C.P & Mohan, B.C. (2018) System for intelligent tourist information using machine learning techniques. *International Journal of Applied Engineering Research*. 13(7): 5321-5327.

Global Food Safety Initiative (2018) *A culture of food safety a position paper from the global food safety initiative.* Available from: http://www.mygfsi.com/images/A_Culture_Of_Food_Safety/GFSI-Food-Safety-Culture-FULL-VERSION.pdf

Harris, F.C., & Lahey, B.B. (1982) Subject reactivity in direct observational assessment: A review and critical analysis. *Clinical Psychology Review*. 2: 523-38.

Haven-Tang, C. & Jones, E. (2008) Labour market and skills needs of the tourism and related sectors in Wales. *International Journal of Tourism Research*. 10(4), 353-363. doi: 10.1002/jtr.666

Haven-Tang, C. & Jones, E. (2013) Capitalising on Rurality: Tourism Micro-businesses in Rural Tourism Destinations. In: P. Somerville & G. Bosworth (Eds.) *Interpreting Rurality: Multidisciplinary Approaches* (pp). Abingdon: Routledge. ISBN 978-0-415-69672-2

Jones, E. & Haven-Tang, C. (2005) Tourism SMEs, Service Quality and Destination Competitiveness. In: E. Jones & C. Haven-Tang (Eds.) *Tourism SMEs, Service Quality and Destination Competitiveness: International Perspectives* (pp.). Wallingford: CABI Publishing. ISBN 0-85199-011-8

Kadariya, J., Smith, T.C & Thapaliya, D. (2014) Staphylococcus aureus and Staphylococcal Food-Borne Disease: An Ongoing Challenge in Public Health. *BioMed Research International*. 2014, Article ID 827965, 9 pages.

Lues, J. F. R. & van Tonder, I. (2007) The occurrence of indicator bacteria on hands and aprons of food-handlers in the delicatessen sections of a retail group. *Food Control*, 18 (4): 326–332

Nam, K., Dutt, C.S, Chathoth, P., Daghfous, A. & Khan, M.S (2020) The adoption of artificial intelligence and robotics in the hotel industry: prospects and challenges. *Electronic Markets*. 1-22

Powell, D. (2010) *Direct observation of food safety skills far better than self-reported surveys*. Available from: http://www.foodsciencecentral.com/fsc/ixid15919

Rossi, M., Stedefeldt, E., da Cunha, D. & de Rosso, V. (2016) Food safety knowledge, optimistic bias and risk perception among food-handlers in institutional food services. *Food Control*. 73: 681-688

Taylor, J. & Holah, J.T. (2000) *Hand hygiene in the food industry: A review*. Review No. 18, Project No. 35461 Campden & Chorleywood Food Research Association.

Taylor, J., Kaur, M. & Walker, H. (2000) *Hand and footware hygiene: An investigation to define best practice*. Confidential R&D report No. 110. Project 29729. Campden & Chorleywood food research association group.

Todd, E.C.D., Greig, J.D., Bartleson, C.A. & Michaels, B.S. (2007) Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 3. Factors Contributing to Outbreaks and Description of Outbreak Categories. *Journal of Food Protection*; 70(2): 199-217

Todd, E.C.D., Michaels, B.S., Smith, D., Greig, J.D. & Bartleson, C.A. (2010) Outbreaks Where Food Workers Have Been Implicated in the Spread of Foodborne Disease. Part 9. Washing and Drying of Hands To Reduce Microbial Contamination. *Journal of Food Protection*. 73(10): 1937-1955.

Walker, E., Pritchard, C. & Forsythe, S. (2003) Food-handlers' hygiene knowledge in small food businesses. *Food Control*. 14(3): 39-43

World Health Organization. (n.d.) *Clean hands protect against infection*. Accessed 4th April 2018 from: http://www.who.int/gpsc/clean_hands_protection/en/