Institution: Manchester Metropolitan University

Unit of Assessment: A3 Allied Health Professions, Dentistry, Nursing and Pharmacy

Title of case study: Interdisciplinary research that enabled EU food SMEs to Improve the hygienic status of food contact surfaces

1. Summary of the impact

This case study describes the impact of interdisciplinary research at MMU that has focused on the development and characterisation of hygienic and antimicrobial surfaces across a range of applications, particularly with regard to food hygiene, which in turn impacts on food quality, reduced waste and consumer health across the international food industry. This 20-year collaboration has enabled identification and specification of properties of putative hygienic/antimicrobial surfaces, whilst testing them in vitro and in situ. This research has had international impacts in areas including health (cross-contamination) hygienic design (food processing), and development of standards for testing novel materials.

2. Underpinning research

2. Underpinning research Publications by microbiologists in the 1980s, on the interactions occurring between cells and surfaces, tended to focus more on the microbiology than the nature of the underlying surface. Professor Joanna Verran *(Professor of Microbiology, MMU – present)* recognised that surface properties affected the retention of cells on surfaces, and that characterisation of the surface was essential in order to manage surface hygiene: real-life surfaces were not smooth, and residual contamination after an ineffective clean would have potential impact on health. MMU's first publication on the subject was in 1991.

From this initial work, a niche cross-disciplinary research area developed, focusing on the effect of topography and chemistry of surfaces on interactions with microorganisms, and the characterisation of the surface across a range of applications, particularly with regard to food-borne illness (*Listeria monocytogenes, Escherichia coli*).

In 1997 – 2001, Professor Verran provided the academic lead on a MAFF-LINK project (which included Unilever, AstraZeneca, BNFL and Campden and Chorleywood Food Research Association), which focused on the characterisation of the effect of wear on the subsequent cleanability of hygienic food contact surfaces **[1].** Normal cleaning routines did not increase fouling of stainless steel by microorganisms, but did affect (impede) removal of organic (food) soil. The detection of organic material on surfaces and assessment of its impact on cleaning and hygienic status of the surface became important **[2].** Characterisation of surface topography was reliant on statistical values (Ra) that were insufficient to explain interaction with microbial cells **[3].** Indeed, subsequent research revealed that the relationship between feature dimension and size of microorganism was key in influencing the strength of the cell-surface interaction **[4].**

Novel use of the atomic force microscope enabled the strength of attachment of microorganisms to surfaces to be assessed. Subsequent work formed a major part of one work package, and impacted on a further two work packages on a large EU project: PathogenCombat (2005 - 2010) - Professor Verran was the MMU partner lead. MMU focused on differentiation between microorganisms and food soil on surfaces, by the development of novel staining techniques to enable useful assessment of cleaning and disinfection protocols, and the development of coated surfaces with defined topography and chemistry, which would eventually potentially enable specification of 'hygienic' surface topography **[5].** These two approaches were novel in research being carried out on open food contact surfaces **[6],** and findings were disseminated by Prof Verran through the publication of a brochure by PathogenCombat designed to inform SMEs and other food processing industries (and the interested public).

This novel combination of microbiology and surface engineering found further impact in the meat processing and brewing industries, where new collaborative projects with Professor Kelly *(Professor of Surface Engineering, MMU 2008 – present),* surface engineer, and European partners are making previous general observations more specific - using microorganisms, surface coatings, cleaning processes and soil appropriate to a given industry or application. Verran and Kelly were submitted together in the Materials and Metallurgy UoA in 2008, reflecting the success of this joint venture.

3. References to the research

[1] *Verran J, Boyd RD, Hall KE and West RH*. 2001. Microbiological and chemical analyses of stainless steel and ceramics subjected to repeated soiling and cleaning treatments J. Food Protect. 64: 1377 - 1387. http://www.ncbi.nlm.nih.gov/pubmed/11563515 *(20 citations)*

[2] *Verran J, Boyd RD Hall KE and West RH.* 2002. The Detection of microorganisms and organic material on stainless steel food contact surfaces Biofouling 18: 167 - 176
DOI: 10.1080/08927010290006736 *(14 citations)*

[3] *Verran J and Boyd R.* 2001.The effect of substratum surface roughness on the retention of microorganisms. Biofouling. 17: 59 – 71, **DOI:** 10.1080/08927010109378465, *(48 citations)*

[4] *Verran J, Packer A, Kelly PJ, Whitehead KA.* 2010a. Use of the atomic force microscope to determine the strength of bacterial attachment to grooved surface features,' Journal of Adhesion Science and Technology, 24: 2271-2285 **DOI:** 10.1163/016942410X508019 *(3 citations)*

[5] *Verran J, Airey P, Packer A, Whitehead KA.* 2008. Microbial retention on open food contact surfaces and implications for food contamination. Adv Appl Microbiol. 64: Chapter 8, 223-246.
DOI: 10.1016/S0065-2164(08)00408-5 *(14 citations)*

[6] *Verran J, Packer A, Kelly PJ, Whitehead KA.* 2010b. Titanium-coating of stainless steel as an aid to improved cleanability,' International Journal of Food Microbiology, 141: S134-S139.
DOI: 10.1016/j.ijfoodmicro.2010.04.027 *(5 citations)*

Relevant grants and contracts to indicate research quality
Between 1997 and 2003, MMU has been involved in projects focusing on surface characterisation and hygiene amounting to over £1m, in addition to being a partner in the Integrated EU Pathogen Combat project (€6m). Since 2003, we have taken leads in relevant projects again approaching £1m.

4. Details of the impact

Significant industrial research funding has demonstrated the impact of our findings and expertise to a wide international community. The EU Framework 6 funded project **PathogenCombat** (2005-2010) aimed *'to make food safer and strengthen consumer trust by monitoring and preventing future pathogens throughout the food chain'*. The overall objective was to provide new essential information and methods to the food industry and public authorities on how to reduce the prevalence of emerging food borne pathogens. Partners encompassed 16 European states and Australia, including 24 Universities, three industrial partners and 17 small and medium-sized enterprises, with a total budget of €14.3m. MMU's focus was on the prevention of cross contamination by hygienic design.

PathogenCombat created significant resources for engagement and research impact amongst an (predominantly) European) audience of Food-related SME's. The website (www.pathogencombat.com) received approximately 120,000 hits per month whilst the project was live (until 2010). Newsflashes regularly featuring findings from MMU's research were sent to subscribers and an MMU authored (Verran) brochure **[A]** on the "cleanability of open food contact surfaces" was circulated to 6000 European food SMEs leading to considerable uptake (150 SMEs) of a PathogenCombat web support system that enabled SMEs to self-assess food hygiene and safety procedures. Verran also contributed to various international stories around the project including articles in The Parliamentary Magazine (2009) http://bit.ly/1cg8ojx and International Innovation Magazine http://bit.ly/1c2bOYK

Confirming MMU's "key" role in the PathogenCombat project is a statement (on file) from the director of the project who attests *"Professor Verran was a key person. Improvement of hygienic design was seen as one of the most important activities in PathogenCombat based on the fact that for about 30% of outbreaks of food borne disease, cross contamination has been reported as a*

main contributing factor…it was a major reason for inviting Professor Verran to become a partner. The outcome (of her activity) was the development of effective hygiene control methods. Professor Verran was heavily involved in preparing brochures specifically addressing industry, SMEs and food inspecting agencies. The brochures have been distributed widely and at present the information has been taken into use by leading players in global food chains." **[B]**

Other evidence of the impact of MMU research in PathogenCombat derives from additional international projects initiated between the MMU research team and individual SME Partners resulting directly from the findings. Between 2009 and 2012, Verran collaborated with the University of Copenhagen on a 4-year Danish Research Council for Technology and Production project focused on transforming the use of antimicrobial metal-coated surfaces in the meat production industry. The project resulted in *"significant new knowledge"* and *"without the contribution of the MMU group could not have been fulfilled satisfactorily"***[C].** Research into antimicrobial photo-catalytic coatings has also been taken forward in a Technology Strategy Board (TSB) funded project with partners in the brewing industry in Finland involving field-testing of novel coated surfaces to reduce contamination **[D].** Our work has consistently reported on the benefits of using stainless steel over other more active surfaces such as copper. We have developed surfaces that are photocatalytic and antimicrobial in the light; and others that are also antimicrobial in the dark, by combining transition metals with photocatalytic titanium dioxide. Our reputation in this field is significant as we are able to combine expertise in microbiology with expertise in surface engineering and physical/chemical characterisation of surfaces and apply this expertise to various industries. For example, in 2012 the International Stainless Steel Association identified Verran and her work as key part of helping them to make a case for the hygienic properties of stainless steel in medical applications. This type of enquiry evidences the impact of our research on international interest in surface characterisation and interaction with microorganisms, and the consequences of these interactions in terms of health and hygiene **[E].**

The evaluation of antimicrobial surfaces provides challenges in terms of appropriate testing methods. Our expertise is now valued in terms of input into the development of **British and international testing standards and guidelines**. Verran is the author of a chapter on "Testing surface cleanability in food processing" which appears in the "Handbook Of Hygiene Control In The Food Industry." Originally published in 2005, this practical handbook is still considered as the *standard reference on high hygiene standards within the food industry* **[F]** and according to the Society for General Microbiology is *"an invaluable tool for any microbiologist working in the food industry".* Professor Kelly is a member of the British Standards Committee; RPI/013: Advanced Technical Ceramics, which focuses on standardisation of photocatalytic testing techniques. Verran was invited to comment on draft standards involving microorganisms, including collaboration with the International Biodeterioration Research Group (IBRG) where tests are being developed by industry towards European Standards **[G].** The current Biocide Product Directive also requires demonstration of effectiveness at point-of-use, again necessitating development of valid test protocols.

MMU hosts a bi-annual international workshop for industrial partners focused on Photocatalytic and Superhydrophilic Surfaces (September 2011 and December 2013) attracting over 50 delegates from 10 countries **[H].**

5. Sources to corroborate the impact

[A] "Factors affecting fouling and cleanability of open food contact surfaces" brochure circulated to 6000 European food SMEs (authored by Verran) available at: http://bit.ly/1i08LFL

[B] Statement on file from Professor Emeritus, University of Copenhagen (Director of PathogenCombat) corroborating both the role and wider impacts of MMU's involvement within Pathogen Combat

[C] Testimonial on file from Associate Professor, University of Copenhagen on the impacts of Danish meat production and hygiene project (2009-12)

[D] Statement available from co-ordinator Matera TSB project corroborating the impact of MMU research on Finnish Brewing industry.

[E] Statement available from Aperam Stainless corroborating MMU's (Verran) role in this international project to apply the hygienic properties of stainless steel to the medical industry.

[F] Link to Handbook of Hygiene Control in the Food Industry http://www.woodheadpublishing.com/en/book.aspx?bookID=832 and http://firatozel.files.wordpress.com/2011/08/handbook_of_hygiene_control_in_the_food_industry.pdf *(Verran is the author of chapter 34, pp 556-568 "Testing Cleanability in Food processing")*

[G] Statement available from member of International Bio-deterioration Research Group (IBRG) (Managing Director) IMSL on MMU's role on supporting EU standards for testing.

[H] MMU photocatalysis conference www.dri.mmu.ac.uk/PSS2011; www.dri.mmu.ac.uk/pss2013