# Work Packages Report Summary & Next Steps

TSA | DMU Disinfection Validation Research Project

**NOVEMBER 2022**

DE MONTFORT UNIVERSITY LEICESTER

# BACKGROUND

The Textile Services Association in partnership with TRSA, ETSA and several other European associations set about creating a test protocol in 2019 to validate every laundry wash process. The need for such a protocol was evident from how different laundry operators used several different types of test methods that helped them interpret the results they wanted. The industry identified the benefits of developing a single test method that measures microbial "kill" with best possible results and practicality. It was essential the objective was backed by good academic research, and few were better placed to lead the project than De Montfort University.

The research has enabled the development of a single test protocol – essentially what 'good' looks like. The learnings through this project have been also immensely useful in implementing additional work packages in 2020 and 2021 as you would find detailed below. We also have a test method that ticks most of the protocol boxes. There are also more details below about the boxes that still need ticking. This will enable industrial laundry operators to validate processes to the full extent and fairly compare results to alternative solutions such as domestic washing machines which may not be able to produce the same standards of microbial kill.

**This strong research foundation then helps in effective lobbying and potential changes in regulatory and policy decisions.**

Five work packages were agreed upon for the project with a technical industry project team regularly reviewing the progress. Following the project launch, the world experienced the COVID pandemic so a further significant addendum was added to the research to establish the survivability of the virus both within wash processes and also on a range of surfaces including textiles.

This Preliminary Report has been put together to inform research partners on the progress of the project to date and to assess the benefit of further research into some of the future challenges that are clearly going to impacting on the laundry industry's ability to continue to drive world hygiene standards.

This report is confidential and should not be distributed outside of the partner associations and no press release should be published to avoid conflict when it comes to peer-reviewing the research results and ultimately publishing the research in medical journals.


## Acknowledgements

Thanks to our funding partners and the project team for supporting this global research initiative.

### Primary Funding Partners

### Funding Partners

# OBJECTIVES AND RESULTS

## WORK PACKAGE 1 | OBJECTIVE

Understand current practices used within the industrial laundry industry for determining elimination of microbiological load to textiles. A data collection exercise was conducted from across the sector to determine current methodologies.

## WORK PACKAGE 1 | RESULTS

All of the current methods employed to assess the decontamination of commercial laundry were gathered and ready for testing.

## WORK PACKAGE 2 | OBJECTIVE

Determine the efficacy of current practices in assessing the bactericidal and sporicidal kill rate of laundering. An array of current practices was used to assess the microbiological efficacy of wash processes under laboratory conditions to fully understand the pros and cons of the microbiological testing being used across the sector. The understanding gained in work package two allowed for the most appropriate methodologies to be used in work package three, in order to establish a best practice standardised microbiological efficacy test for assessment of laundry processes.

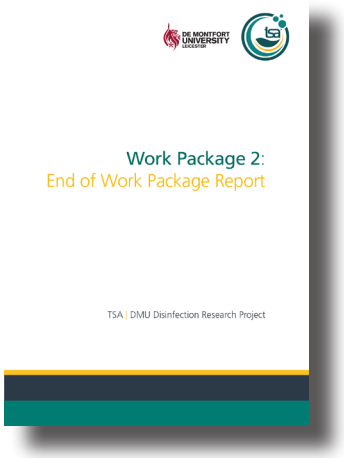
## WORK PACKAGE 2 | RESULTS

Comparisons of commercially available biological indicators and inoculated swatches for wash testing demonstrated that microorganisms are lost due to dilution and agitation within the wash process during swatch testing, whereas this loss was ameliorated within biological indicators due to the presence of a semi-permeable membrane.

Further investigations of the biological indicators suggest that commonly used disinfectants and detergents were able to cross the semi-permeable membrane in a typical healthcare wash programme.

## WORK PACKAGE 2 | REPORT

Work packages 1 and 2 reports need to be maintained confidential just until the peer-review process has been completed with WP6. We cannot wait to make it available for our partners at the right time.



# OBJECTIVES AND RESULTS ...cont'd

## WORK PACKAGE 3 | OBJECTIVE

Use the information gained in work package 2 to develop a microbiological test method that measures the kill rate of a laundry process on bacteria and spores. If an existing test method is adequate at measuring the kill rate of bacteria and spores, then this will be adopted. Otherwise, produce a standardised test method that can be replicated in a competent microbiology laboratory that produces a consistent measurement of bacterial and spore kill rates in a wash process.

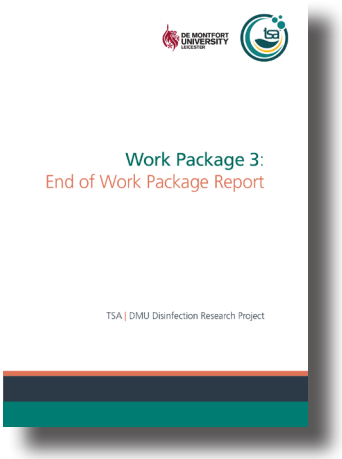
## WORK PACKAGE 3 | RESULTS

Bioindicators are permeable to common bleaching agents at ambient temperature (peracetic acid, sodium hypochlorite, hypochlorous) however they are impermeable to detergent compounds such as SDS at lower temperatures (ambient to 60°C), and are thus cannot certify laundering processes employing cooler temperatures than 60°C. Nylon membranes were investigated as alternatives to commercially available bioindicators; these membranes are permeable to bleaching agents but are not permeable to detergents even at 60°C. Nylon membranes are therefore not suitable for purpose as semi-permeable membranes for use in industrial wash processes.

Commercially available bioindicators are recommended as the most suitable method for determining the kill of microorganisms during laundering, however further development of alternative membranes that are permeable to detergents at low temperatures may be required in the future to ensure that all laundry technologies are encompassed by one method.

## WORK PACKAGE 3 | REPORT

Work package 3 report needs to be maintained confidential just until the peer-review process has been completed with WP6. We cannot wait to make it available for our partners at the right time.



# OBJECTIVES AND RESULTS ...cont'd

## WORK PACKAGE 4 | OBJECTIVE

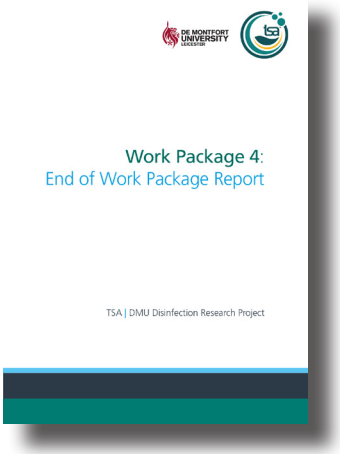
Ascertain the most appropriate standardised test protocol for use within the industrial laundry arena to determine the bactericidal and sporicidal efficacy of wash/disinfection processes- Using the most robust efficacy testing methods a new protocol for microbiological testing of laundry was established. The methods were evaluated during all stages of the wash and against the most commonly used detergents. This was then evaluated against Gram-positive and Gram-negative bacteria and bacterial spores.

## WORK PACKAGE 4 | RESULTS

1. The bioindicator membrane is not permeable to detergents at 50°C, suggesting that their use is limited to processes at 60°C and above.
2. Bioindicators are not permeable to ozone under typical in-use conditions, i.e. in the presence of temperature (40°C) and detergent.
3. Bacillus subtilis bioindicators contain pure spores at $10^6$ CFU/swatch and therefore may be suitable for use in assessing the efficacy of wash processes against spores.
4. The semi-quantitative method was somewhat comparable to the quantitative method, however there were some discrepancies in calculated log reduction. In particular, the log reduction of Escherichia coli may be overestimated due to the lower than expected starting inoculum. Another disadvantage is that $\log_{10}$ reduction of B. subtilis spores below 6 $\log_{10}$ cannot be calculated due to bioindicators only containing a 6 $\log_{10}$ CFU swatch. This is being highlighted with the DES-controllers supplier.
5. E. coli was completely reduced by both domestic (60°C) and industrial (67 and 75°C) washes.
6. Industrial wash cycles with and without detergent (67-75°C) passed current validation requirements (≥5 $\log_{10}$ reduction) for Enterococcus faecium whereas only domestic laundering with biological detergent passed the requirements.
7. B. subtilis spores were reduced by 1.7 $\log_{10}$ by industrial laundering with detergent, but was not reduced by temperature alone in industrial wash cycles nor by domestic laundering with and without detergent.

## WORK PACKAGE 4 | REPORT

Work package 4 report needs to be maintained confidential just until the peer-review process has been completed with WP6. We cannot wait to make it available for our partners at the right time.



# OBJECTIVES AND RESULTS ...cont'd

## WORK PACKAGE 5 | OBJECTIVE

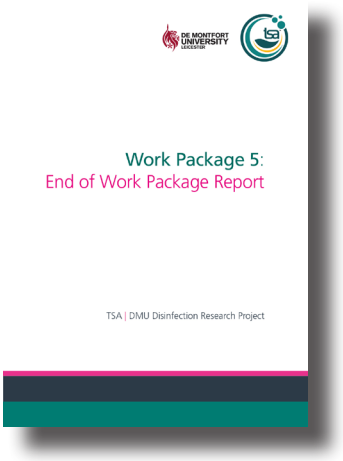
Roll out new microbiological testing protocol to the laundry sector (post laboratory-based project) - The TSA/other funding bodies will be responsible for any data they wish to publish in collaboration with DMU. The new standardised microbiological testing protocol will be rolled out through industry networks as a best practice standard within the laundry industry. There may be potential for the new test protocol to be reflected in HTM 01-04 and BS EN 14065.

## WORK PACKAGE 5 | RESULTS

Elis and Micronclean are testing the protocols in their labs and are comparing the data with the DMU lab results. Cardiff University colleagues have been also asked to cross-check the efficacy of the protocol and methodologies.

## WORK PACKAGE 5 | REPORT

Work package 5 report needs to be maintained confidential just until the peer-review has been completed with WP6. We cannot wait to make it available for our partners at the right time.



# OBJECTIVES AND RESULTS ...cont'd

## ADDITIONAL WORK PACKAGE (COVID RESEARCH) | OBJECTIVE

To assess the survival of SARS COV-2 in various commonly used textiles. Additionally, the survivability of SARS COV-2 in a range of washing parameters including dilution, agitation, heat and detergents.

## ADDITIONAL WORK PACKAGE (COVID RESEARCH) | RESULTS

**Survivability of virus on common fabric types.**

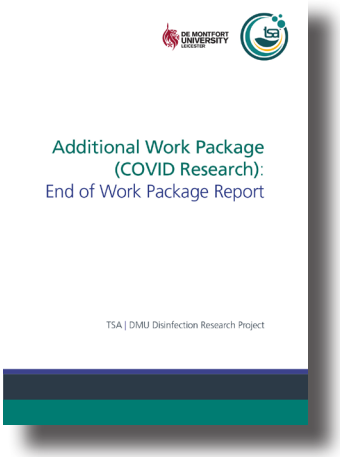
1. The tested strain of coronavirus (HCoV-OC43) remained infectious on polyester fabric for at least 72 hours, 100% cotton for 24 hours and a blended polycotton (50/50) for 48 hours.
2. The virus was demonstrated to transfer to other surfaces from polyester fabric for up to 72 hours, suggesting that textiles may be a fomite transmission risk within the healthcare and domestic environments.

**Survivability of virus in various wash parameters:**

1. Model coronaviruses can remain infectious in water alone at temperatures up to 60°C for 10 minutes
2. Traces of the viruses were found after laundering in a washing machine at ambient temperature in the presence of interfering substances (artificial saliva).
3. When agitation, temperature and detergent are combined, no trace was found at 40°C and above.

## ADDITIONAL WORK PACKAGE (COVID RESEARCH) | REPORT

Click here to access the published research paper. Interestingly, this report has already been downloaded just from one journal over 2,000 times.



# OBJECTIVES AND RESULTS ...cont'd

## ADDITIONAL WORK PACKAGE (TEMPERATURE VALIDATION) | OBJECTIVE

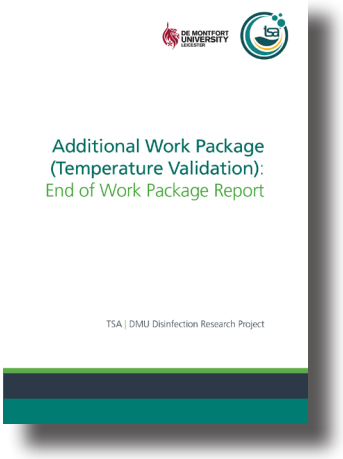
The aim of this addendum was to determine the disinfection efficacy of an industrial wash cycle against Enterococcus faecium, Escherichia coli and Bacillus subtilis spores enclosed within commercially available bioindicators at a range of temperatures and times to understand the time-temperature relationship and point of decontamination failure.

## ADDITIONAL WORK PACKAGE (TEMPERATURE VALIDATION) | RESULTS

Thermal disinfection of E. faecium is achieved at a minimum of 70°C for 3 minutes. E. coli is more sensitive to thermal disinfection, with a complete reduction in viable cells being achieved by a 3-minute wash at 50°C. B. subtilis spores are resistant to thermal disinfection, with 0.06-0.29 $\log_{10}$ reductions after 10 minutes of washing at 88-90°C.

## ADDITIONAL WORK PACKAGE (TEMPERATURE VALIDATION) | REPORT

This work package report needs to be maintained confidential just until the peer-review process has been completed with WP6. We cannot wait to make it available for our partners at the right time.



## EXECUTIVE SUMMARY OF KEY FINDINGS AND NEXT STEPS

- The industry now has a single test protocol that proves microbiological kill.
- A test methodology that works above 60°C enabling more efficient thermal disinfection requirements subject to satisfactory test results saving global energy resources.
- Coronavirus does not present additional temperature or chemical requirements within a wash process (easy to disinfect).
- Current thermal validation protocols (by temperature alone) can be reduced to 70°C for 3 minutes.
- Current thermal validation protocols are not effective against spores which were thermally resistant at 90°C.
- Domestic washing machines produce inconsistent results and cannot be relied upon to hygienically clean products (report available).
- A test methodology with the potential to validate a chemo-thermal process against spore forms that currently are not 'killed' by temperature alone.

## CHALLENGES DISCOVERED

- Spore forms still require further investigation within a chemo-thermal process.
- Safety levels of test microorganisms need to be lowered from Biosafety level 2 to Biosafety level 1.
- Bio-indicator test is the closest we can get to an ideal solution. However, the current membrane is not permeating the disinfectants below 60°C. Please note, if the bio-indicator is validating the 'kill' below 60°C, it is a valid result. The question arises only if the test fails whether it is a false negative.
- No alternatives to the commercially available DES controllers.
- Ozone did not pass the test possibly due to the failure to penetrate the membrane.

# NEXT STEPS

## FUNDING WORK PACKAGE 6 (EXTENSION OF THE CURRENT PROJECT)

To address the challenges identified above, with regard to the efficacy of the test methodology, predominantly around developing a membrane that works in lower temperatures, we have developed and mapped the scope of this extension. The estimated total cost is in the region of £35,000.

This work package is critical to the success of the overall success of the project. Before committing to the full scope, early trials were conducted to ensure the likelihood of a successful outcome.

| Research Title | Scope | |
|---|---|---|
| Extension of the current project (work package 6) | • Further investigation into alternative membranes<br>• Development of test methodology to work at lower temperatures<br>• Collating of all WP findings into final peer-review submission | |

## OZONE

Whilst the current test methodologies do not allow the testing of ozone processes, it is felt important for the industry to include ozone within this research scope. Potentially, this technology will be part of the solution towards lower temperature washing. Chemo-thermal processes are going to form a key part of the drive to a lower energy future. Following conversations with EUOTA, it was agreed that they would work with DMU and other universities to develop an acceptable validation process preferably a bio-indictor solution.

| Research Title | Scope | |
|---|---|---|
| Ozone wash process validation | • Ozone concentration measurements<br>• Further investigation into membranes that would permeate Ozone<br>• Ozone process validation (a bio-indicator option preferred) | |

# FUTURE MICROBIOLOGICAL HURDLES

During the research further topics of microbiological research have been identified as beneficial to our industry and have the potential, if not fully understood, to create real obstacles in the future, particularly with the drive to lower temperatures and increased attention on hygiene with the development of resistant viruses and spores.

It is felt advantageous that our industry is aware of these potential hurdles and manages the conversation early on.

These include the following topics;

- Assess downstream laundry processes and their impact on spores and other pathogens i.e. ironing, tumbling, tunnel finishing and so on
- Management of biofilms within the commercial/industrial washing equipment
- Assessment of biofilms in domestic washing equipment and on-premise-laundry equipment
- The ability for pathogens to survive and transfer from a surface to surface including skin and textiles.
- Ability of retail/domestic dry/wet-cleaning processes to disinfect across a range of pathogens.

### Funding

The most cost-effective solution to this long-term research is to continue to work with the expertise of the DMU microbiology department under the leadership of Prof. Katie Laird, but provide the resource through the sponsorship of a PhD student. This enable the project to be cost-effective and spread over a three year period enabling some agility with the eventual outcomes as the research develops.

| Research Title | Scope | | |
|---|---|---|---|
| Future Microbiological Hurdles and Potential Solutions for The Industrial Laundry Sector | • A literature review of all relevant industry knowledge assets with a commentary on relevance against each line item. This is a good opportunity to share the expertise and partner with other research organisations e.g. Hohenstein, Satra, Intertek, ARTA<br>• Assess downstream laundry processes and their impact on spores and other pathogens i.e. ironing, tumbling, tunnel finishing etc.<br>• Management of biofilms within the wash machine environment. The ability for pathogens to survive & transfer from a surface to surface including skin and textiles.<br>• Ability of retail/domestic dry/wet-cleaning processes to disinfect across a range of pathogens. | | |

# APPENDIX

## THE RESEARCH TEAM AT DE MONTFORT UNIVERSITY

Prof Katie Laird has a PhD in applied microbiology and is a Chartered Biologist, she is aProfessor of Microbiology and Head of the Infectious Disease Research Group at De Montfort University. Katie specialises in antimicrobial product development and infection control, with a particular interest in healthcare textiles, her background as a fabric technologist for Aquascutum gives her further insight on textile properties in order to successfully conduct research in this area. Katie has patented antimicrobial products in her academic role, as well as working with international companies on product development and antimicrobial product efficacy testing, including those in the textile industry.

Prof Laird has conducted extensive research on healthcare laundry assessing the efficacy of both domestic and industrial laundering and has multiple publications in this area (listed below). Her knowledge of laundering processes and developed methodologies for determining the efficacy of washing systems, alongside her product development expertise makes Katie well placed to lead the proposed project.

The research team at DMU includes Dr Maitreyi Shivkumar a Senior Lecturer in virology who specializes in the survival of viruses on surfaces including textiles, Dr Lindsay Apps a Senior Lecturer in psychology with extensive expertise in assessing attitudes within the healthcare environment as well as a microbiology research team including PhD students and Post Doctoral researchers with a range of expertise in both applied and molecular microbiology.

## RESEARCH FACILITIES

Role out of new microbiological testing protocol to the laundry sector (post laboratory-based project) - The TSA/other funding bodies will be responsible for any data they wish to publish in collaboration with DMU.

The new standardised microbiological testing protocol will be rolled out through industry networks as a best practice standard within the laundry industry. There may be potential for the new test protocol to be reflected in HTM 01-04 and BS EN 14065.

The Covid-19 research will be supported by Dr Maitreyi Shivkumar (Lecturer in Virology).

# RELEVANT PUBLICATIONS

## PAPERS


1. Owen, L., Apps L, Stanulewicz, N, Hall, A & Laird, K. (2022) Knowledge, behaviour and attitudes of healthcare uniform laundering: A UK survey of healthcare workers during the COVID-19 (coronavirus) pandemic. American Journal of Infection Control. https://doi.org/10.1016/j.ajic.2021.12.017
2. Owen L, Shivkumar M, Cross R, and Laird K. (2021) Porous surfaces: stability andrecovery of coronaviruses. Interface Focus 20210039. https://doi.org/10.1098/rsfs.2021.0039
3. Soroh, A, Owen, L., Rahim,N., Masania, J., Abioye, A., Qutachi, O., Goodyer, L., Shen, J., and Laird, K. (2021) Microencapsulation of essential oils for the development of sustainable antimicrobial and mosquito repellent functional coatings for textiles. Journal of Applied Microbiology http://doi.org/10.1111/jam.15157
4. Owen L, Shivkumar M, Laird K. (2021).The stability of model human coronaviruses on textiles in the environment and during healthcare laundering. mSphere 6:e00316-21. https://doi.org/10.1128/mSphere.00316-21.
5. Owen, L. & Laird, K. (2020). Development of a Silver-Based Dual-Function Antimicrobial Laundry Additive and Textile Coating for the Decontamination of Healthcare Laundry. Journal of Applied Microbiology; 130 (4): pg 1012-1022 https://doi.org/10.1111/jam.14850
6. Owen L, Laird K. (2020). The role of textiles as fomites in the healthcare environment: a review of the infection control risk. PeerJ 8:e9790 https://doi.org/10.7717/peerj.9790
7. Grancaric, A.M, Laird, K., Botteri, L., Shen, J., and Laatikainen, K., (2020), Microencapsulation for improved mosquitoes' repellent efficacy of cotton fabrics. IOP Conference Series: Materials Science and Engineering, 827. https://iopscience.iop.org/article/10.1088/1757-899X/827/1/012056
8. Tarrant, J., Jenkins, R., & Laird, K. (2018), From Ward to Washer: The Survival of Clostridium difficile spores on Hospital Bedsheets through a Commercial UK NHS Healthcare Laundry Process. Infection Control and Hospital Epidemiology. 0, 1–6
9. Riley, K., Owen, L., Williams, J., Davis, A., Shen, J. and Laird K. (2017), The Effect of Low Temperature Laundering and Detergents on the Survival of Escherichia coli and Staphylococcus aureus on Textiles Used in Healthcare Uniforms. Journal of Applied Microbiology, 123:(1), 280-286.
10. Riley, K., Laird K. and Williams J. (2015) Washing healthcare uniforms at home: Adhering to hospital policy. Nursing Standard. 29, 25, 37-43.


## PAPERS UNDER REVIEW


1. Tarrant, J., Jenkins, R. & Laird, K. (2019), Influence of the exosporium on adherence of C. difficile spores to cotton bed sheets. Letters in Applied Microbiology.


## PRACTITIONER PUBLICATIONS


1. Laird, K. (2018) Laundering to kill Germs: Microbiological Decontamination of Textiles. Mapping Educational Specialist knowHow (MESH), available from http://www.meshguides.org (Peer Reviewed)
2. Laird K, Williams, J & Riley K (2018) Domestic laundering of nurses' uniforms: what are the risks? Nursing Times [online]; 114: 2, 18-21. (Peer Reviewed)
3. Environmental Special Interest Group UK (contributor Laird, K.) Healthcare Technical Memorandum (2018), Cleaning and Disinfection Quality: Guidance standards for establishing and assessing cleaning and disinfection in UK Hospitals and other healthcare facilities.


## BOOK CHAPTERS


1. Laird, K. Soroh, A. & Shen, J. (2021), Microencapsulation of Essential Oils for Antimicrobial Function and Mosquito Repellency, Bio-mathematics, Statistics and Nano-Technologies: Mosquito Control Strategies. Taylor & Francis Group CRC Press/Chapman & Hall.
2. Laird, K. & Owen, L. (2018), The role of protective clothing in healthcare and its decontamination. Decontamination in hospitals and healthcare. Woodhead publishing, 2nd Edition. IN PRESS
3. Riley, K & Laird K. (2016), Antimicrobial Textiles for Medical Environments, Antimicrobial Textiles, Elsevier
4. Laird, K. Riley, K. and Williams, J. (2014) The role of protective clothing in healthcare and its decontamination. Decontamination in hospitals and healthcare. Woodhead publishing.

# RELEVANT PUBLICATIONS ...cont'd

## INVITED SPEAKER

1. Owen, L., Shivkumar, M., Apps, L. and Laird, K. (2022) Laundering healthcare uniforms at home: risks during the COVID-19 pandemic. Infection Prevention and Control Conference, Birmingham, 26th April 2022.
2. TSA Knowledge Network Open Day. Efficacy of Microbial Test Methodologies for Laundry 9th February 2022 [Online].
3. National Health Executive 365: Infection Control in NHS Estates: Leader's debate, infection control, online, 16th December 2021
4. British Footwear Association, Global Industry Webinar, The life of covid on leather, 24th November 2021
5. Textiles Rental Services 10th Annual Healthcare Conference, Stability of coronaviruses on textiles and during laundering: Are healthcare textiles a COVID-19 infection control risk? Texas USA, 17-18th November 2021
6. Textiles National Congress, Efficacy of Microbial Test Methodologies for Laundry, Birmingham, UK, 10th November 2021
7. National Health Executive 365: Infection, prevention and Decontamination: Decontamination Panel Discussion, online, 23rd June 2021
8. Infection Prevention Society, Yorkshire Branch Meeting, Stability of coronaviruses on textiles and during laundering: Are healthcare textiles a COVID-19 infection control risk? online, 23rd March 2021
9. Textile Services Association, COVID-19 and Healthcare Laundry Global Trade Association Webinar, Stability of Model Human Coronaviruses on a Range of Textile Fibre Types, online, 19th Jan 2021.
10. Infection Control and Prevention; Knowlex (Knowledge Exchange for the NHS), Are Textiles and Infection Control Risk, Birmingham, Feb 2020
11. TRSA 8th Annual Healthcare Conference & Exchange, Session Title: Current Healthcare Market-Related Research Review: Research to Develop a New Standardised Test Method to Determine the Antimicrobial Efficacy of Laundry Processes. San Diego, Nov 2019.
12. Textile Services Association, Annual Conference, Healthcare Textiles Research: Nurses Uniforms and Bedsheets, Warwick, UK, Sept 2019
13. Society of Hospital Linen Services and Laundry Managers Conference, Barnsley, C. difficile the gremlin of hospital bedsheets, May 2018.
14. Textile Rental Services Association (TRSA), Low Temperature washing of Nurses Uniforms, USA, September 2017 via webinar
15. Infection Control and Prevention Conference; Knowlex (Knowledge Exchange for the NHS), Domestic Laundering of Nurses Uniforms: The Effect of Low Temperature Laundering, Leeds, 12th July 2017.
16. European Textile Services Association (ETSA), Hygiene of Domestic Laundering – Evaluating Risks and Opportunities. Paris 14th-16th of June
17. Infection Control and Prevention; Knowlex (Knowledge Exchange for the NHS), Domestic Laundering of Nurses Uniforms: The Effect of Low Temperature Laundering, London, Feb 2017.
18. Society of Hospital Linen Services and Laundry Managers Conference; Stratford-Upon-Avon, Domestic Laundering of Healthcare Uniforms, May 2016
19. TSA Autumn Conference, Bugs: Are they really dead? Healthcare Textile Research: Nurses Uniforms and Bedsheets, September 2019
20. TRSA Healthcare Membership presentation, Study on Clostridium difficile spores and Correlation between temperature and chemicals in disinfecting spores in a laundry process, November 2019

# RELEVANT PUBLICATIONS ...cont'd

## CONFERENCES

### American Society of Microbiology Conference

- Tarrant, J. Jenkins, P. & Laird, K. How clean are your Hospital Beds?, American Society of Microbiology General Meeting, peer reviewed abstract (New Orleans), May 2015. Awarded outstanding poster.

### Society for Applied Microbiology

- Tarrant, J. & Laird, K. Brighton, July 2014: Clostridium difficile spores and healthcare laundry policy: How clean is your hospital bed?
- Tarrant, J. & Laird, K. Dublin, July 2011: Assessment of methods for recovery of Clostridium difficile spores from textiles.
- Owen, L., Shivkumar, M. and Laird, K. (2021) Persistence of human coronaviruses on textiles during laundering. March 23rd 2021 [online poster presentation].
- Shivkumar, M., Adkin, P., Owen, L., Patel, J., Shantharamu, U., Goodyear, L. and Laird, K. (2022) Stability of Human Coronavirus OC43 on Leather and Viral Transfer to Different Surfaces. SfAM Early Career Scientist Research Symposium, Cardiff, 20th June 2022.

### Textile Institute World Conference

- Riley, K., Laird, K. & Williams, J. Shah Alam, Malyasia, May 2012: How closely do hospital staff follow NHS guidelines on domestic laundering procedures? (oral presentation).

### Australian Society for Microbiology

- Riley, K., Laird, K. & Williams, J. Melbourne, July 2014: Can fibre type have a role in the reduction of microorganism survival on healthcare uniforms?

### Infection Prevention Society

- Owen, L., Cripwell, L., Hook, J., Shivkumar, M. and Laird. K. (2021) Disinfection of laundry using low temperature validated ozone system, OTEX, against human coronavirus HCoV-OC43. 13th Annual conference Liverpool, 27-29 September 2021
- Owen, L. Silver, K. and Laird, K. (2022) Variable Decontamination Efficacy of Domestic Washing Machines: Potential Risks for Home Laundering of Healthcare Uniforms. 14th Annual conference, Bournemouth, 17th-19th October 2022 [oral presentation].

### ITMC

- Grancaric A M, Laird K, Botteri L, Shen J and Laatikainen K, Microencapsulation for Improved Mosquitoes Repellent Efficacy of Cotton Fabrics, ITMC 2019 Conference, Marrakech, Morocco, 13-15 November 2019.

### ECCVID

- Owen, L., Shivkumar, M. and Laird, K. (2020) Stability of Model Human Coronaviruses on a Range of Textile Fibre Types. ESCMID Conference on Coronavirus Disease, 23-25th September 2020 [online].

### ECCMID

- Owen, L. and Laird, K. (2020) Dual-Function Antimicrobial Laundry Supplement and Textile Coating for the Decontamination of Healthcare Laundry. ECCMID, Paris, April 2020 [poster]. Abstract only published
- Owen, L., Apps, L., Stanulewicz, N., Hall, A. and Laird, K. (2021) Knowledge, attitudes and behaviours of UK healthcare workers towards uniform laundering polices during the COVID-19 pandemic. European Congress on Clinical Microbiology and Infectious Diseases, 9-12th July 2021, online [poster].
- Adkin O P and Laird K. (2021) The interactions of bacterial contamination with healthcare mattress textiles specifically designed to repel microorganisms. European Congress of Clinical Microbiology & Infectious Diseases, 9-12th July 2021, online [poster].
- Owen, L. and Laird, K. (2022) Evaluation of current healthcare laundry hygiene monitoring methodologies. ECCMID, online, 23-26th April 2022 [poster].