

BIOGRAPHICAL SKETCH

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NAME: Kath Bogie

eRA COMMONS USER NAME (credential, e.g., agency login): KBOGIE

POSITION TITLE: Associate Professor/ Senior Research Scientist

EDUCATION/TRAINING (*Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.*)

INSTITUTION AND LOCATION	DEGREE (if applicable)	Completion Date MM/YYYY	FIELD OF STUDY
University of Manchester Institute of Science and Technology, Manchester, UK	B.Sc.(Hons.)	06/1984	Metals and Materials Technology
University of Oxford, Oxford, UK	D.Phil.	08/1998	Biomedical Engineering

A. Personal Statement

Too many people experience recurring musculoskeletal damage leading to pressure injury and ischemic wound development. Musculoskeletal integrity is directly impacted as these chronic wounds destroy the soft tissue of the skin and muscle and can extend down to and into the bone. My translational research includes studies to determine why some people experience a continuous cycle of pressure injuries while others remain pressure injury free. I also lead the development of technology and interventions for effective musculoskeletal wound therapy and prevention. I have over 20 years' experience leading multidisciplinary teams including biomedical engineers, electrical engineers, clinicians, biologists and statisticians to develop and evaluate novel clinically –focused approaches from biomarkers to device development and population risk factors. I have experience in all aspects of study oversight, including monitoring budgets, complying with regulatory requirements for both human and animal studies and adhering to stated goals and timelines. I mentor students with a variety of backgrounds including biomedical engineers and clinician researchers. As Director of the CWRU Additive Manufacturing for Biotechnology Core I provide support for the development and testing of novel biomedical approaches incorporating additive manufacturing to improve the quality of life and health for all.

B. Positions and Honors**Professional Experience**

1984-1985 Research Assistant, North Staffordshire Bio-Medical Engineering Unit, Stoke-on-Trent, UK
 1989-1994 Associate Clinical Scientist, Queen Mary and Westfield College, University of London, London, UK.
 1989-1992 Research Bioengineer, National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, UK
 1992-1994 Consultant Bioengineer, Tissue Viability Clinic, National Spinal Injuries Centre, Stoke Mandeville Hospital, Aylesbury, UK
 1997-2001 Research Associate, Case Western Reserve University, Cleveland, Ohio
 2001-2009 Senior Research Associate, Dept of Orthopaedics, Case Western Reserve University, Cleveland, Ohio
 2004-present Senior Research Scientist, Cleveland Dept of Veterans Affairs Medical Center
 2009-2017 Adjunct Assistant Professor (Primary), Dept of Orthopaedics, Case Western Reserve University, Cleveland, Ohio
 2009-2017 Adjunct Assistant Professor (Secondary), Dept of Biomedical Engineering, Case Western Reserve University, Cleveland, Ohio
 2010- 2013 Research co-Director, Advanced SCIM Fellowship Program, Cleveland Dept of Veterans Affairs Medical Center
 2010 - 2014 Site Director, DETECT (Diagnostic Engineering Technologies for Evaluating Connective Tissues), Wright Center for Sensor Systems Engineering, Ohio Third Frontier Wright Projects Program
 2013 Director, Health Monitoring and Maintenance Research, Advanced Platform Technology Center, Cleveland Veterans Affairs Medical Center, Cleveland, Ohio

- 2013 Director, Biocompatibility Testing Lab, Cleveland Dept. of Veterans Affairs Medical Center, Cleveland, Ohio
- 2013 Director, Additive Manufacturing for Biotechnology Core, Case Western Reserve University
- 2017 Associate Professor, Dept of Orthopaedics, Case Western Reserve University, Cleveland, Ohio
- 2018 Member, ISO/TC 173/SC 1/WG 11 Wheelchair Seating Standards Committee
- 2019 Member (elected), Collaborating Organization Council, National Pressure Ulcer Advisory Panel
- 2019 Member, Education Committee, National Pressure Ulcer Advisory Panel

Other Experience and Professional Memberships

Grant Reviews: *National:* National Science Foundation, VA Rehabilitation Research and Development Service, National Institutes of Health, Lytmos Group, American Institute of Biological Sciences, Deployment Related Medical Research Program, Congressionally Directed Medical Research Program, James and Esther King Biomedical Research Program, VA Joint BLR&D and CSR&D Services, Paralyzed Veterans of America Research Foundation *International:* British Lung Foundation, Singapore National Medical Research Council, Romanian National Council for Development & Innovation, Hong Kong Health and Medical Research Fund

Journal Reviewer: Archives of Physical Medicine and Rehabilitation, J Rehabil Research and Development, JBJS, Neuromodulation, Medical Science Monitor, Clinical Orthopaedics & Related Research, Annals of Biomedical Engineering, Muscle and Nerve, Physiological Measurement, Journal of Spinal Cord Medicine, Journal of NeuroEngineering and Rehabilitation, JBJS Reviews, J Biomolecular Technology, JBJS Reviews, International Wound Journal, Physiological Reports, Experimental Biology and Medicine, Clinical Rehabil., Journal of Rehabilitation and Assistive Technologies Engineering

Editorial Board: Journal of Tissue Viability, PLoS Rehabilitation Channels, Journal of Rehabilitation and Assistive Technologies Engineering

Conferences & meetings: Organizing Faculty, 6th Annual Conference of the International FES Society; Faculty, Workshop on “Scientific Basis of Neurorehabilitation for Spinal Cord Injury and Stroke, American Society of Neurorehabilitation; Course Director & Scientific Chair, 1st & 2nd International Evidence-based Practice in Wound Care Chair, Expert panel for development of PU implementation research agenda, VA HSR&D Quality Enhancement Research Initiative

Consultant: Sunrise Medical Ltd. (UK), Cleveland Medical Devices, Hill-Rom Medical, Guidepoint Global (Clinical Advisors) LLC, Neocure Group LLC, Avery Medical

Other: Judge, Internet Science and Technology Fair, Member, Wound Healing Society Education Committee, Faculty Member, Dept of Genetics Imaging Advisory Committee, CWRU, Subject Matter Expert, Rehabilitation Research(DEU), Dept of Veterans’ Affairs, Advisor, Neurotechnology for Brain Injury Fact Sheet, Contributor, Wound Healing Society White paper on Wound Care Certification, Subject matter expert reviewer Pressure Ulcer Prevention and Treatment Following Injury: A Clinical Practice Guideline, Consortium for Spinal Cord Medicine. Steering Committee Member, Women Faculty of the School of Medicine, CWRU

International Standards Organization: Member, ISO/TC 173/SC 1/WG 11 Wheelchair seating

Honors

- 2007 Featured in Case Western Reserve University 2006-7 Edition of *The Value of Research*
- 2007 Invited attendee, National Academies Keck Futures Initiative “The Future of Human Healthspan”
- 2009 Featured in lead article of US Medicine “*Pressure and Time: The Two Combined Can Equal Pressure Ulcers*”
- 2009 Invited keynote speaker. Hong Kong Association of Rehabilitation Medicine Annual Scientific Meeting, “*Pressure Ulcer Management: Before and After Tissue Breakdown*”
- 2010 Who's Who in America, 2010-2011 Edition.
- 2011 Invited speaker, Synergy Seminar, Austen BioInnovation Institute in Akron, Akron, Ohio *Challenges posed by chronic wounds*
- 2011 Invited speaker, 14th Annual Meeting of the European Pressure Ulcer Advisory Panel, Porto, Portugal, *The role of neuromuscular electrical stimulation in pressure ulcer prevention*
- 2014 Invited speaker, Shear and Tissue Integrity - the state of the science. ISO Standards group, London, UK. *Practical challenges in clinical assessment of soft tissue shear: where we are now and future potentials.*
- 2016 Invited speaker, Heal Ohio 2016, Akron, OH. *From the 19th Century to today: Electrotherapy for chronic wounds*
- 2017 Graduate, FLEX Women Faculty of SoM Leadership Development Program, Class of 2016-17
- 2017 Invited attendee, National Academies Keck Futures Initiative “Beyond Boundaries”
- 2018 Invited speaker, Association for the Advancement of Wound Care Pressure Ulcer Summit, Atlanta, GA *What lies beneath: Tissue health biomarkers indicate why pressure mapping alone cannot tell the full story*
- 2018 Elected member, Board of Directors, Wound Healing Society

2019 Invited speaker, Best Overall Contribution to the Field, National Pressure Ulcer Advisory Panel Annual Conference, St Louis, MO.

Toward a better understanding of why pressure mapping alone cannot reliably predict pressure injury risk: investigation of underlying key factors.

C. Contributions to Science

1) **Chronic wound therapeutic interventions:** Translational research in the area of wound therapy has included studies of the physiological effects of electrotherapy on chronic wounds. In a preliminary pre-clinical study, we developed and tested our novel patented Modular Adaptive Electrotherapy Delivery System (MAEDS). This technology provides all components of a single-channel, programmable current-controlled electrotherapy system within a lightweight, flexible, independently-powered portable device. A systematic and quantitative study of the efficacy of various stimulation paradigms in a small animal model found that clinically appropriate electrotherapy can more than double the proportion of ischemic wounds closed by 3 weeks. Lower currents inhibited ischemic wound healing, setting a lower bound on the effective therapeutic window.

- a. **Bogie KM**, Garverick SL, Zorman CA, Howe DS. Integrated surface stimulation device for pain management and wound therapy. Patent #: 9320907 awarded April 26, 2016
- b. Graebert J, Henzel MK; Honda KS, **Bogie KM**. Systemic evaluation of electrical stimulation for ischemic wound therapy in a pre-clinical in-vivo model. *Advances in Wound Care* 2014, 3(6): 428-437. PMID: 24940557
- c. Howe DS, Dunning J, Zorman C, Garverick SL, **Bogie KM**. Development of an integrated surface stimulation device for systematic evaluation of wound electrotherapy. *Ann Biomed Eng.* 2015 Feb;43(2):306-13. PMID: 25274162.
- d. **Bogie KM**. The Modular Adaptive Electrotherapy Delivery System (MAEDS): An Electroceutical Approach for Effective Treatment of Wound Infection and Promotion of Healing. *Mil Med.* 2018 Nov 5. [Epub ahead of print] PMID: 30395273.
- e. Sui Y, Kreider LP, **Bogie KM**, Zorman CA, Fabrication of a silver-based thermistor on flexible, temperature-sensitive substrates using a low-temperature inkjet printing technique. *IEEE Sensors Letters* 2019 Feb 3(2) IEEEXplore Jan 2019

2) **Pressure injury prevention and risk management:** The primary prevention of chronic wounds, such pressure injuries, in at-risk populations is a challenging issue, due in no small part to the multiple factors that play into both the specific condition and the overall clinical profile of individuals at risk. Early in my career I developed a tissue viability clinic for the assessment of individuals with spinal cord injury (SCI) and developed a multivariate tissue health assessment tool that facilitated quantitative non-invasive evaluation of tissue health. This tool has been used by others to gain insight in to factors such as effective pressure relief (Coggrave & Rose, 2003). We have also developed a tool to obtain more useful information from interface pressure mapping and carried out a clinical study which found that a 10-minute assessment can reliably indicate tissue health and that tissue may adapt to applied load over time. I have led preliminary studies to determine approaches to determination of personalized risk for pressure injury development, including development of the Biomarkers for Early Identification of Pressure Injury Risk (BEIPIR) model. I led development of the SCI Pressure Ulcer Database (SCIPUD), which includes multiple relevant intrinsic and extrinsic factors that may be associated with pressure injury prevention and healing in SCI. In preliminary analysis, we observed that factors previously found to be predictive of initial pressure injury development may not, in fact, be predictive of repeated hospital admissions for ongoing pressure injury care.

- a. Wu GA, **Bogie KM**. Not just quantity: gluteus maximus muscle characteristics in able-bodied and SCI individuals - implications for tissue viability. *J Tissue Viability.* 2013 Aug;22(3):74-82. PMID: 23615320
- b. Goodman BL, Schindler A, Washington M, **Bogie KM**, Ho CH. Factors in rehospitalisation for severe pressure ulcer care in spinal cord injury/disorders. *J Wound Care.* 2014 Apr; 23(4):165-6, 168, 170-2 passim. PMID: 24762380
- c. Lemmer D, Alvarado N, Henzel MK, Richmond M, McDaniel J, Graebert J, Schwartz K, Sun J, **Bogie KM**. What lies beneath: Why some pressure injuries may be unpreventable for individuals with spinal cord injury *Arch Phys Med Rehabil.* 2018 Dec 6. pii: S0003-9993(18)31512-0. [Epub ahead of print] PMID: 30529322.
- d. **Bogie KM**, Zhang GQ, Roggenkamp SK, Zeng N, Seton J, Tao S, Bloostein AL, Sun J. Individualized Clinical Practice Guidelines for Pressure Injury Management: Development of an Integrated Multi-Modal Biomedical Information Resource. *JMIR Res Protoc.* 2018 Sep 6;7(9): e10871. PMID: 30190252; PMCID: PMC6231753.

3) **Pressure injury prevention- dynamic intermittent gluteal stimulation (iGSTIM):** I conducted innovative clinical feasibility studies using a percutaneous iGSTIM system. We showed that regular daily use of dynamic iGSTIM has a positive impact on tissue health, including increased muscle thickness and blood flow together with reduced regional interface pressures. In addition to the long term changes in muscle characteristics, dynamic iGSTIM alters conditions at

the seating support interface due to periodic changes in interface pressure facilitated by stimulated muscular contractions. We also examined the effects of sub-threshold 'sensory' stimulation and that it had no impact on quantitative measures of tissue health.

- a. **Bogie KM**, Triolo RJ. The effects of regular use of neuromuscular electrical stimulation on tissue health. *J Rehabil Res Dev.* 2003; 40(6): 469-475. PMID: 15077659
- b. **Bogie KM**, Wang X, Triolo RJ. Long term prevention of pressure ulcers in high risk individuals: a single case study of the use of gluteal neuromuscular electrical stimulation. *Arch Phys Med Rehabil*, 2006; 87(4): 585-91 PMID: 16571402
- c. Kim J, Ho CH, Wang X, **Bogie K**. The use of sensory electrical stimulation for pressure ulcer prevention. *Physiother Theory Pract.* 2010 Nov; 26(8): 528-36. PMID: 20649492
- d. Wu GA, Lombardo L, Triolo RJ, **Bogie KM**. The effects of combined trunk and gluteal neuromuscular electrical stimulation on posture and tissue health in spinal cord injury. *P M R.* 2013 Aug;5(8):688-96. PMID: 23542776.

4) **Assessment and development of wheelchair seating:** Core assistive technology for persons with limited mobility includes a wheelchair seating system with an effective pressure relief cushion. An effective cushion prevents tissue breakdown, promotes postural stability and increases overall sitting tolerance. I led a study to evaluate the effects of passive weight-shifting produced by an active pressure relief cushion. Multivariate tissue health outcomes and user satisfaction were assessed in a using a repeated measure longitudinal study design. Working with collaborative, interdisciplinary team, I have also led development of a novel low-cost, high performance cushion using value-driven engineering principles to break the link between cost and efficacy in wheelchair seating. Our cushion uses advanced dynamic materials to create a modular support system which can be customized for individual seating requirements at very low cost.

- a. **Bogie KM**, Freeto T, Fitting System and Method for Modular Pressure Relief Cushion. U.S. Utility App. No.: 15/461,520. Filed: March 17, 2017
- b. Freeto T, Mitchell SJ, **Bogie KM**. Preliminary development of an advanced modular pressure relief cushion: Testing and user evaluation. *J Tissue Viability* 2018; 27(1):2-9. PMID: 28343746.
- c. Freeto T, Cypress A, Amalraj S, Yusufshaq MS, **Bogie KM**. Development of a sitting microenvironment simulator for wheelchair cushion assessment. *J Tissue Viability.* 2016 Aug;25(3):175-9. PMID: 27067837.
- d. Wu GA, Garber SL, **Bogie KM**. Utilization and user satisfaction with alternating pressure air cushions: a pilot study of at-risk individuals with spinal cord injury. *Disabil Rehabil Assist Technol.* 2016 Oct;11(7):599-603. PMID: 25799879.

5) **Multidisciplinary research in chronic wound management:** Throughout my career I have worked with interdisciplinary teams. I have written 8 chapters and 12 invited papers on the area, including teaching and novel approaches. In conjunction with clinical colleagues, I developed an interdisciplinary meeting, as the Scientific Chair bringing together national and international experts to speak about their work and share ideas. In conjunction with this conference, I obtained funding to convene a one-day 'think-tank' meeting of invited conference faculty and thought leaders to develop a consensus on the critical research gaps to be addressed to improve current evidence-based knowledge in pressure injury care and facilitate large scale implementation of advanced clinical practice. We developed a consensus paper that set priorities on four categories: risk factors, clinical management, education and environment of care. It was concluded that many critical multidisciplinary targets for primary pressure injury research remain, which overlaps with my focus area on wound prevention.

- a. **Bogie KM**, Ho CH, Terris DD. Clinical evidence for new pressure ulcer treatment modalities. *Long-Term Care Interface.* 2005 June; 43-47
- b. **Bogie K**, Ho CH. Multidisciplinary approaches to the pressure ulcer problem. *Ostomy Wound Management.* 2007; 53(10): 26-32. PMID: 17978412
- c. Ho CH, **Bogie K**. Integrating Wound Care Research into Clinical Practice *Ostomy Wound Management.* 2007; 53(10): 18-25, PMID: 17978411
- d. Henzel MK, **Bogie KM**, Guihan M, Ho CH. Pressure ulcer management and research priorities for patients with spinal cord injury: Consensus opinion from SCI QUERI Expert Panel on Pressure Ulcer Research Implementation. *J Rehabil Res Dev.* 2011; 48(3):xi-xxxii. PMID: 21480093

6) **Wound measurement:** Throughout my research it has become clear that effective management of chronic wounds requires reliable quantitative measures of healing. Reliable wound measurement is a critical component of any comprehensive wound assessment protocol in both research and clinical care. In a pilot study to assess the accuracy of surface area measurement techniques we found that electronic devices are superior to manual techniques in achieving valid measurements of wound area. We then evaluated 3-D wound measurement as a reliable tool to provide quantitative assessment of changes in wound dimensions during healing. We found that a reliable measurement of wound status that

can be obtained using this system by nursing personnel without having to depend on the limited resources of the specialist wound care nurse. Thus, the system could be implemented with high measurement reliability in healthcare settings. We carried out a quality improvement study to provide telehealth care for veterans with chronic wounds. We have also used this advanced wound imaging data to develop a model for personalized prediction of chronic wound healing. We found that accurate monitoring of wound geometry can adaptively predict healing progression and that accuracy of the prediction curve improves with each additional evaluation.

- a. Haghpanah S, **Bogie KM**, Banks PG, Wang X, Ho CH. Reliability of electronic vs. manual wound measurement methods. *Arch Phys Med Rehabil.* 2006; 87(10):1396-402. PMID: 17023252
- b. Davis AJ, Nishimura J, Seton J, Goodman BL, Ho CH, **Bogie KM**. Repeatability and clinical utility in stereophotogrammetric measurements of chronic wounds. *J Wound Care.* 2013 Feb; 22(2):90-2, 94-7. PMID: 23665664
- c. Xu Y, Sun J, Carter RR, **Bogie KM**. Personalized prediction of chronic wound healing: An exponential mixed effects model using stereophotogrammetric measurement. *J Tissue Viability.* 2014 Apr 18. pii: S0965-206X(14)00028-X. PMID: 24810677

Complete List of Published Work in MyBibliography (44 peer reviewed papers, 9 chapters, 7 invited reviews)

http://www.ncbi.nlm.nih.gov/sites/myncbi/collections/public/1Rok1sZA_i4t782Z5SHM4VF5d/?sort=date&direction=ascending

D. Research Support

Ongoing Research Support

Bogie (PI) 05/18-04/21 Department of Veterans Affairs

Development of advanced personalized modular pressure relief seating cushion systems: Testing and user evaluation

A pilot clinical study of the next-generation low-cost high-performance customizable modular pressure relief cushion will be carried out. 3D printing will be used to build cushions with *SquishINS* inserts and personalized modular cushions created using our cushion fitting process. User satisfaction will be measured along with the effects on daily function, skin status and seated tissue health.

Bogie (PI) 09/17-08/20 DOD CDMRP SCIRP Translational Research Award

Toward effective pressure ulcer prevention: Development of a flexible implanted stimulator for improved gluteal muscle quality and regular weight shifting

This translational study will use advanced additive manufacturing and flexible electronics to develop *flexSTIM*, a mechanically biomimetic and functionally flexible 4-channel, implanted pattern generator to drive a fully implanted dynamic intermittent gluteal stimulation (iGSTIM) system for effective pressure ulcer prevention.

Bogie (PI) 03/17-04/21 Department of Veterans Affairs

Toward smart personalized electrotherapy for enhanced healing of ischemic wounds

The study will provide translational development and testing in a swine model of the Smart Modular Adaptive Electrotherapy Delivery System (SmartMAEDS) for treatment and remote monitoring of chronic ischemic wounds.

Bogie (PI) 09/15-08/19 DOD CDMRP SCIRP

Toward personalized pressure ulcer care planning: development of a bioinformatics system for individualized prioritization of clinical practice guidelines

The study will develop and test a multivariate structural model of risk factors occur associated with primary and secondary PU/DTI to provide clinicians with a tool for developing personalized care plans.

Triolo (PI) 03/10 – 12/19 Department of Veterans Affairs

Advanced Platform Technology Center of Excellence Role: Investigator

The APT Center ensures that the most recent developments in micro-electronics, nanotechnology, and material science are applied to clinically relevant problems in the rehabilitation of veterans.

Recently Completed Research Support

Bogie (PI) 01/15-12/18 Craig H. Nielsen Foundation

Development of a personalized pressure ulcer /deep tissue injury risk tool

The project used an applied research case-control study design to develop and test a new outcome tool for pressure ulcer and deep tissue injury risk assessment for individuals with long-standing SCI.

Bogie (PI) 09/14-08/18 DOD CDMRP SCIRP

Development of a personalized model for pressure ulcer prevention acutely following spinal cord injury: Biomarkers of muscle composition and resilience

The study identified individual PU risk characteristics acutely following spinal cord injury as a basis for development of a clinical tool to optimize personalized pressure relief.