Project Details	
Project Code	MRCPHS25Ca Farnell
Title	Improving Bruise Evidence Across Variations in Skin Tone Using Artificial Intelligence
Research Theme	Population Health Sciences
Summary	Bruises are often seen on victims of violence in accident and emergency departments or as part of paediatric examinations. Bruising predicts later hospitalisation and homicide. Collecting reliable bruise evidence is essential in safeguarding those at risk of violence, especially domestic violence. However, darker skin tones can obscure bruises. Our ongoing research exploits novel imaging techniques to detect and evidence bruising across all skin tones. This project will use artificial intelligence (AI) to maximise information extracted from such images, including creation of "explainable" rules on bruise causation and visualisation, with great impact involving the NHS, social services, and police in Wales.
Description	**Background:** Violence inflicts considerable healthcare costs on victims, families, and the NHS. The NSPCC estimated that 51,510 in the UK were at risk of physical abuse in 2023. For both adults and children, bruising is a common indicator often seen at Accident & Emergency departments or as part of a paediatric medical examination. However, darker skin colours mask bruising; bruises mature and appear differently to those observed in pale skinned individuals. Racial groups with darker skin are disadvantaged potentially when it comes to the identification of abuse and intentional injury, as it is more difficult for those with a safeguarding role to observe such damage. We have developed novel imaging techniques to detect and evidence bruising across all skin tones. But this is for nothing if we do not also have practical software tools to extract the information from them efficiently and to visualise both images and results effectively. **Methods**: Deep Learning (Goodfellow, MIT Press 2016) is a subset of AI based on neural networks. Such techniques are often "opaque," that is, the system acts a "black box," giving perhaps accurate results, but no indication as why or how the result was achieved. In the real world, it is crucial to let frontline staff such as social workers, nurses and doctors, and police officers know "what to look out for" in such images in order that they can make an informed choice. Explainable AI (XAI) is a new approach that aims to extract meaningful rules and visualisations from the application of machine learning methods. Here we will use model-specific "post-hoc" explainability that extracts such information from existing AI models (Angelov et al., Wiley Interdisciplinary Reviews: Data Mining and Knowledge Discovery 11(5), e1424, 2021). Another critical step is to implement them in the real-world in order to address inequality in bruise evidence and safeguarding in conjunction with stakeholders such as the NHS, social services, and police in Wales. Provision of Data: Bruise image data will come from a variety of sources to mitigate any risk of lack of images as a "bottleneck" in the project. The list of data sources is discussed explicitly and in the section on "anticipated additional project costs per year" below (please this section therefore for details), although we note briefly here that we will use bruise image data that we already access to, including "ground truths" (Dataset A), a prospective bruise imaging study currently underway

	(Dataset B), and police bruise image data with rich covariate data (Dataset C). There should be no danger of a lack of image data therefore. Project timeline: In conjunction with supervisors, the student will steer the direction of the project (including setting research objectives), as well as solving specific technical problems (below). The student will be involved in decision making at all points. However, broad research aims and timeline for the project are: • Months 1-3: Successful completion of the 3-month settling in period, including training & starting a literature review. • Months 4-12: Research Aim 1: Initial exploration when the student will learn how to identify optimal CNN network architectures to localise bruises in images & apply validation techniques by using Dataset A, which includes ground truths / masks. Evidence of completion of learning shown by the submission of a paper to Journal of Visual Communication in Medicine (impact factor = 1.4) & a first-year report. • Months 13-24: Research Aim 2: The student will learn how to apply CCNs to predict the data "labels" using Datasets B & C. Labels are: causal implement (e.g., bite, hands, head, blunt instrument); intensity, size, age, and shape of the bruise; reason for bruising (e.g., accidental or deliberate). Evidence of learning: Journal of Computer Methods & Programs in Biomedicine (impact factor = 6.1) & of a second-year report. • Months 25-33: Research Aim 3: The student will discover how to extract "meaningful rules" and effective visualisations via XAI for the models created for Research Aim 2 using Datasets B & C. Evidence of learning: Journal IEEE Transactions on Image Processing (impact factor = 10.6) & of a third-year report. • Months 34-39: Research Aim 4: The student will explore how this research can be translated into the real world via online surveys of stakeholders to gather views (quantitative and text-based qualitative information), especially about how bruise presentation / visualisation might be used most effectively and how (X)AI might be embedded in decision making. Evidence of completion of learning shown by the submission of a conference presentation and thesis. • Months 40-45: Completion & submission of the PhD thesis. Application for a transition to independence for the GW4 Biomed for the student for further studies along these lines and exploration of practical translation of results. • Months 46-48: Successful completion of a three-month industrial placement.
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