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Evolving Care: Quality Improvement Approaches for Accelerating Translational Impact

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Abstract
The following abstract book showcases the research conducted by undergraduate students who presented at the 2026 Queen's Healthcare and Sciences Research Workshops (QHCSRW) hosted at Queen's University. The conference theme "Evolving Care: Quality Improvement Approaches for Accelerating Translational Impact", aims to highlight recent advances in translational medicine and explores how these innovations are transforming patient care and quality of life. The top three abstracts from the conference are included in the abstract book. For more information, please visit our Instagram @hcs.research.workshops

Keywords: translational medicine; quality improvement; healthcare innovation; student research conference

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Conference Abstracts

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Convolutional Neural Network–Multilayer Perceptron Fnirs Cap for Early Onset Alzheimer's Risk Scoring and Targeted Prevention

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Introduction: Early onset Alzheimer's Disease (AD), affects 3.9-million people worldwide, primarily in their midlife, leading to irreversible neurodegeneration and brain atrophy. AD is mainly diagnosed through MRI brain imaging. However, MRIs only detect macroscopic changes and cannot identify early microscopic markers of AD. Functional near-infrared spectroscopy (fNIRS) is a non-invasive, portable, and cost-effective neuroimaging technology that uses non-ionizing light to measure cerebral blood flow via optical sensors placed on the scalp. By measuring O2 levels in the brain, fNIRS can identify hypoxic regions before plaque formation, informing prevention-based treatment and improving current MRI imaging technology.
Methods: This study evaluates a self-administered midlife fNIRS cap platform that uses a multimodal AI model to generate individualized Alzheimer's risk scores for adults aged 33–50. Participants meeting early-onset risk criteria complete a brief digital questionnaire on medical history, lifestyle, and cognition, then wear a lightweight prefrontal fNIRS cap for 20-minute semiweekly sessions over one month, including a 5-minute resting baseline and a 15-minute adaptive working-memory task. Oxyhemoglobin and deoxyhemoglobin changes and head motion are continuously recorded. A convolutional neural network (CNN) learns patterns from fNIRS-derived activation maps, while a multilayer perceptron (MLP) processes structured data

such as age, blood pressure, smoking, and family history. The model integrates CNN and MLP outputs in a fusion layer to generate a continuous Alzheimer's risk score using both neurovascular signals and clinical factors.
Anticipated Results: The system will generate a novel quantitative Alzheimer's-susceptibility score indicating the risk of early-onset or later-life AD. The score is adapted from the existing SpO2 score with an additional combination of clinical risk factors (age, family history, APOE status, vascular risks) and fNIRS-derived neurovascular patterns. Higher scores align with multiple risk factors and abnormal fNIRS patterns; lower scores with efficient brain responses.
Implications: This positions fNIRS as a novel, low-cost, and accessible tool for early Alzheimer's disease risk screening. This informs prescription interventions at earlier timepoints to reduce AD-associated morbidity.
Conclusion: These findings suggest that fNIRS-CNN-MLP fusion yields significant scores for prefrontal oxygenation and medical history, outperforming MRI for early hypoxia detection in midlife, and enabling early onset AD prevention.

Enhancing the Efficiency and Comparability of Cerebrovascular Reactivity Measurements Using a Streamlined Multi-Paradigm Fmri Pipeline

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Introduction: Cerebrovascular reactivity (CVR) measured using blood oxygen level-dependent functional MRI (BOLD fMRI) is a critical marker of cerebrovascular health, reflecting the capacity of cerebral vessels to dilate in response to vasoactive stimuli. Impaired CVR is associated with elevated stroke risk in multiple diseases, including sickle cell disease (SCD), moyamoya disease, and large-vessel stenosis. Although multiple fMRI-based paradigms exist to measure CVR, including resting-state, breath-hold, and controlled end-tidal CO2 challenges, their clinical translation has been limited due to paradigm-specific processing workflows, substantial manual intervention, and poor integration into routine clinical pipelines. The objective of this study is to develop and evaluate a fully automated, multi-paradigm CVR analysis pipeline capable of producing standardized CVR outputs while improving processing feasibility in a clinical research setting.
Methods: We propose a fully automated CVR analysis pipeline that analyzes data generated from multiple CVR paradigms within a single framework using Python and the FMRIB Software Library. Our pipeline will incorporate validated preprocessing techniques, including brain extraction, motion correction, spatial smoothing, and anatomical registration, paradigm-specific regressor generation, and first-level general linear modeling to compute voxel-wise CVR maps. Outputs will be normalized, aggregated within tissue masks, and automatically registered to the MNI152 linear standard space, enabling direct cross-paradigm comparison. A pilot cohort to test our pipeline will consist of approximately 80 participants with SCD recruited through clinical imaging studies and age-matched healthy controls. Mean whole-brain CVR differences will be assessed using two-tailed Welch's t-tests. Feasibility outcomes will include total processing time per subject compared with an existing semi-manual pipeline.
Results: We anticipate that participants with SCD will demonstrate significantly reduced whole-brain CVR compared with healthy controls across paradigms. Our pipeline is also expected to reduce operator-dependent processing time and variability relative to semi-manual approaches.
Conclusion: An automated multi-paradigm CVR pipeline may improve the feasibility and standardization of CVR analysis by reducing manual processing burden while producing comparable physiological findings across paradigms. Demonstration of feasibility in our pilot cohort would support future work evaluating clinical interpretability, computational scalability, and the role of standardized CVR metrics in cerebrovascular risk assessment.

Assessing the Feasibility of Carefall: An Activity-Specific Fall Risk Assessment Tool to Prevent Patient Falls

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Introduction: In the United States, one million patients fall annually, leading to injuries and deaths, reports from nurses as "second victims", and substantial costs of $80 billion. Currently, the Johns Hopkins Fall Risk Assessment Tool (JHFRAT) is a clinical solution that directs staff attention to high-risk patients. However, JHFRAT has inconsistent predictive sensitivity, fails to highlight movement-specific risks, and unnecessarily restricts patients despite having walking abilities. CareFall addresses this gap by assessing patient-specific high-risk activities.

Methods: A pilot observational study will assess the feasibility and performance of CareFall in classifying fall-risk during specific activities. Hospitalized participants over 60 years will be recruited and divided to the experimental group from outpatient fall clinics and a control group with no history of falls. Throughout their hospital stay, participants will wear an inertial measurement unit (IMU) clip on each shoe and surface electromyography (sEMG) electrodes on their medial and lateral gastrocnemius. These capture gait and muscle activity, respectively, during sit-to-stand, stand-to-sit, and walking movements. The IMU sensor collects multiple metrics, including angular velocity (AV). sEMG analyzes deviations in muscle activities. Once hospitalization finishes, the assessment will end. Collected data will continuously be sent to a cloud-based analysis system, and machine learning will generate a risk category (low, medium, high) based on the magnitude and consistency of deviations from typical movement patterns.
Results: Literature shows that sEMG can identify the three movements and that impaired gait and muscle activation are involved in fall risk. These metrics are anticipated to vary in patients of different activity-specific fall risk. For example, AV is anticipated to differ in timing, magnitude and pattern.
Conclusion: Metrics on activity-specific fall risk classification reveal underlying mobility patterns not captured by JHFRAT. Existing literature advocates for early prevention rather than immediate prediction of falls. Once implemented in hospitals, patients wearing the device would perform a 6-Minute Walk Test with additional sit-to-stand movements. The collected data will categorize patients into activity specific fall risks, which will be sent to a software platform. Given the aging population and nurse shortages, CareFall improves workflow and personalizes fall prevention. Future studies can evaluate the effectiveness of combining JHFRAT and CareFall.

Conflicts of Interest
The author(s) declare that they have no conflict of interests.

Authors' Contributions
MP: Events Director for the Healthcare and Sciences Research Workshops (HCSRW); liaised with the Undergraduate Research in Natural and Clinical Science and Technology (URNCST) Journal; developed the case competition timeline, managed logistics, and served as the primary point of contact for participants; contributed to formatting and drafting the conference abstract book; and gave final approval of the version to be published.
VZ: Member of the events planning committee; coordinated case competition logistics and communications with participants; and gave final approval of the version to be published.
FM: Member of the events planning committee; coordinated case competition logistics and communications with participants; and gave final approval of the version to be published.
PB: Co-President of the Healthcare and Sciences Research Workshops (HCSRW); led planning of the annual conference and case competition and provided executive leadership; reviewed and approved final abstracts for submission; and gave final approval of the version to be published.
OC: Co-President of the Healthcare and Sciences Research Workshops (HCSRW); led planning of the annual conference and case competition, overseeing the events team and providing executive leadership; reviewed and formatted the final conference abstract book for submission; and gave final approval of the version to be published.

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