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# Dementia Assessments in Older Adults: Behavioural and Clinical Markers of Risk

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Submitted in partial fulfilment of the requirements for the degree of
Doctorate in Clinical Psychology

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# Chapter 1

Prevalence of Mild Behavioural Impairment Domains and Risk of Progression to Dementia: A Systematic Review and Meta Analysis

Prepared in accordance with the author requirements for

*Neuroscience & Behavioural Reviews*

https://www.sciencedirect.com/journal/neuroscience-and-biobehavioral-reviews/publish/guide-for-authors

## Abstract

**Background**: Mild behavioural impairment (MBI) describes emergent neuropsychiatric or behavioural symptoms in later-life and is a prodromal marker of all-cause dementia. MBI is a heterogenous syndrome, and domain-level symptoms differ in frequency and prognostic associations with dementia. This review aimed to estimate pooled prevalence of MBI domains in cognitively normal, subjective cognitive decline, and mild cognitive impairment individuals, and evaluate incident dementia risk associated with MBI and its domains.

**Methods**: PubMed, PsycINFO, and Scopus databases were searched (2012-April 2026). Cross-sectional prevalence and longitudinal risk studies of non-dementia adults aged ≥50 and meeting diagnostic MBI criteria were included. Risk of bias was assessed using the Joanna Briggs Institute for prevalence and Cochrane Quality in Prognosis Studies. Random-effects meta-analyses pooled prevalence and hazard ratios; heterogeneity was assessed using $I^2$. Narrative synthesis was undertaken where meta-analysis was inappropriate.

**Results**: 26 studies met inclusion criteria, with six included in the meta-analysis. Pooled prevalence showed consistent domain patterns. Affective dysregulation and impulse dyscontrol were most prevalent, whilst social inappropriateness and abnormal perception/thought were the least prevalent. Prevalence increased alongside cognitive decline. Pooled hazard ratios showed an inverse pattern, with the least frequent domain, abnormal perception/thought, showing the greatest dementia risk. Supplementary meta-analyses included 12 studies that assessed MBI across one-month and ≥6-months.

**Discussion**: Heterogeneity was substantial, and most studies were non-population-based or limited by non-persistent MBI measures. Overall, findings integrating prevalence and risk across domains support MBI as a relatively common prodromal syndrome associated with increased dementia risk. This review was registered on PROSPERO (CRD420251247550).

# Introduction

Dementia is a significant global healthcare priority (Shah et al., 2016), with 139 million people estimated to be living with dementia by 2050 (Jin et al., 2023). There remain no curative treatments, and its growing prevalence places a substantial burden on individuals, caregivers, healthcare systems, and societies (Shah et al., 2016). Increasingly, research has focused on early detection and interventions to prevent or delay dementia progression. The recognition of dementia-related changes beginning well before clinical diagnosis creates opportunities to identify at-risk individuals during prodromal and pre-dementia stages (Jin et al., 2023). Improved identification and characterisation of these individuals has therefore become a key international research priority (Shah et al., 2016).

Approaches to understanding dementia risk have historically focused on cognitive and biological markers; the cognitive axis to neurodegenerative disease (Jin et al., 2023). Although biomarker research has advanced understanding of underlying disease processes, accessibility limits screening approaches (Aytulun & Erden-Aki, 2022). This has increased interest in clinically accessible markers that may complement existing approaches. Neuropsychiatric symptoms (NPS) have long been recognised as pervasive across dementia syndromes and a core feature of clinical phenotypes (Lyketsos et al., 2011). NPS are associated with detrimental effects for individuals with dementia and their caregivers, contributing to worsening outcomes, accelerated functional decline, lower quality of life, and greater caregiver burden (Jin et al., 2023; Lyketsos et al., 2011). NPS in older adults may precede cognitive decline and therefore expand opportunities for dementia risk identification beyond cognition alone (Aytulun & Erden-Aki, 2022; Taragano et al., 2008). This gap was addressed through conceptualisation of mild behavioural impairment (MBI) (Ismail et al., 2016), which describes emergence of late-life neuropsychiatric or behavioural symptoms that are not better explained by other psychiatric or neurological diagnoses, and considered an early indicator of underlying neurodegenerative disease.

The concept of MBI was first proposed as an early manifestation of frontotemporal dementia (FTD) and there was initial uncertainty regarding whether MBI preceded or co-occurred with Mild Cognitive Impairment (MCI) (Ismail et al., 2016; Taragano et al., 2008). The International Society to Advance Alzheimer's Research and Treatment (ISTAART) began refining criteria

for MBI in 2012 and formal diagnostic criteria was proposed in 2016 (Ismail et al.; Table 1). MBI consists of five specific symptom domains: affect, motivation, impulse control, social appropriateness, and perception and/or thought content. Symptoms must persist for at least six-months. MBI can co-occur with MCI, however functional difficulties are driven by neuropsychiatric/behavioural changes rather than cognitive decline. The revised diagnostic criteria highlighted MBI as a prodromal risk for all-cause dementia rather than FTD specifically, given evidence associating MBI with Alzheimer's Disease (AD), Dementia with Lewy Bodies, and Vascular Dementia (Ismail et al., 2016). MBI therefore reflects the behavioural axis to dementia progression, paralleling MCI as the cognitive axis and unifying the dementia development framework (Ismail et al., 2021; Jin et al., 2023; Figure 1).

*Table 1: ISTAART MBI Diagnostic Criteria – Adapted with Permission from Ismail et al., 2016*

1. Changes in behaviour or personality observed by patient, informant, or clinician, starting later in life (age ≥50 years) and persisting at least intermittently for ≥6 months. These represent clear change from the person's usual behaviour or personality as evidenced by at least one of the following:
    a. Decreased motivation (e.g., apathy, aspontaneity, indifference)
    b. Affective dysregulation (e.g., anxiety, dysphoria, changeability, euphoria, irritability)
    c. Impulse dyscontrol (e.g., agitation, disinhibition, gambling, obsessiveness, behavioural perseveration, stimulus bind)
    d. Social inappropriateness (e.g., lack of empathy, loss of insight, loss of social graces or tact, rigidity, exaggeration of previous personality traits)
    e. Abnormal perception or thought content (e.g., delusions, hallucinations)
2. Behaviours are of sufficient severity to produce at least minimal impairment in at least one of these areas:
    a. Interpersonal relationships
    b. Other aspects of social functioning
    c. Ability to perform in the workplace

    The patient should generally maintain independence of function in daily life, with minimal aids/assistance.
3. Although comorbid conditions may be present, the behavioural or personality changes are not attributable to another current psychiatric disorder (e.g., generalised anxiety disorder, major depression, manic or psychotic disorders), traumatic or general medical causes, or physiological effects of a substance or medication.
4. The patient does not meet criteria for a dementia syndrome (e.g., Alzheimer's disease, frontotemporal dementia, dementia with Lewy bodies, vascular dementia, other).

    MCI can be concurrently diagnosed with MBI.

*MBI: Mild behavioural impairment; MCI: mild cognitive impairment*

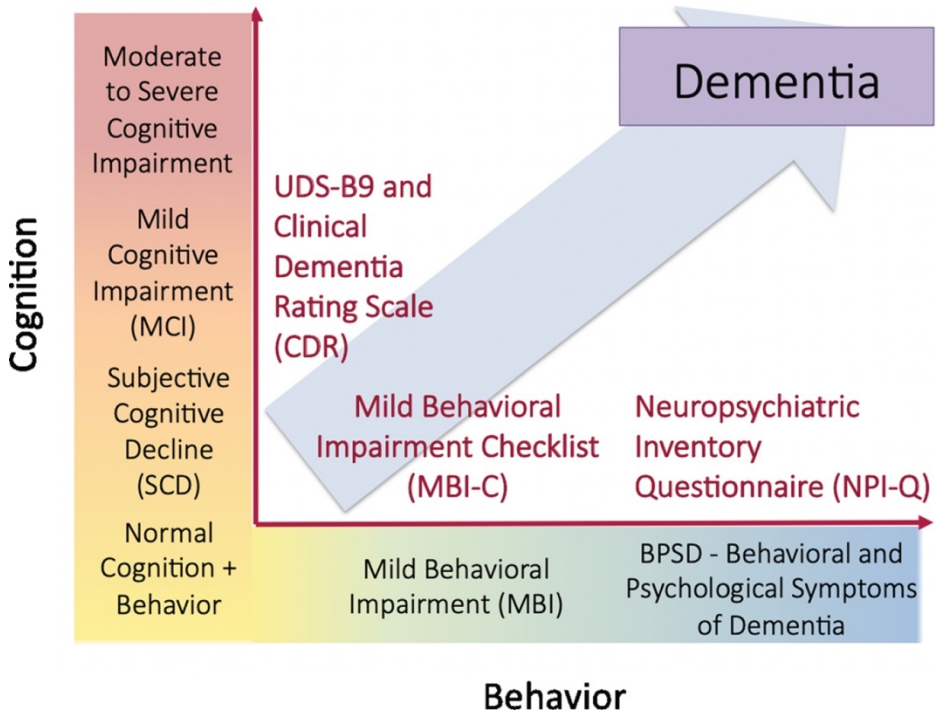



*Figure 1: Dementia Risk Axes – Redrawn with Permission from Ismail et al., 2021*

In the last decade, growing evidence has supported the conceptualisation and value of MBI as prodromal to dementia (Guan et al., 2024), although this remains a relatively new concept. The MBI-Checklist (MBI-C) was developed and validated as an instrument to assess and identify this syndrome in non-dementia older adults and includes 34-items easily administered with self, informant, or clinician-reports (Ismail et al., 2017). The measure was developed based on the ISTAART criteria and provides a valid estimation of MBI domains (Ismail et al., 2017). However, given its relatively recent development and validation, most MBI literature has relied on existing measurement tools (Jin et al., 2023). The Neuropsychiatric Inventory (NPI) and the briefer NPI-Questionnaire (NPI-Q), informant-rated tools assessing NPS and neurovegetative symptoms, have most commonly been used, by translating items onto ISTAART MBI domains (Mortby et al., 2018; Sheikh et al., 2018;). 10 NPS domains from the NPI/NPI-Q are mapped onto the five MBI domains (Table 2), with two neurovegetative domains, sleep and appetite changes, removed as these are not represented in the ISTAART criteria (Mortby et al., 2018). Although NPI-derived MBI estimates are not without limitations, this approach is widely used and has contributed substantially to the growing evidence-base (Jin et al., 2023).

*Table 2: NPI Mapped onto ISTAART MBI Domains – Adapted with Permission from Mortby et al., 2018*

| | ISTAART MBI Domains | | | | |
|---|---|---|---|---|---|
| | Decreased Motivation | Affective Dysregulation | Impulse Dyscontrol | Social Inappropriateness | Abnormal Perception/Thought Content |
| NPI domains | G. apathy/ indifference | D. depression/ dysphoria<br>E. anxiety<br>F. elation/ euphoria | C. agitation/ aggression<br>I. irritability/ lability<br>J. aberrant motor behaviour | H. disinhibition | A. delusions<br>B. hallucinations |

Systematic and meta-analysis reviews have explored MBI prevalence across cognitive groups, including Cognitively Normal (CN) and/or MCI individuals, and individuals with Subjective Cognitive Decline (SCD) (Pan et al., 2020; Zhao et al., 2025). Research has focused less on domain prevalence, however. A valuable systematic review on domain-level prevalence was completed by Pan and colleagues in 2021, with detailed sensitivity and meta-regression analyses, however important gaps were noted. The limitation of studies estimating MBI with a one-month reference range was highlighted (Pan et al., 2021). This was therefore carefully considered in this review to ensure added value to the evidence-base, as research has also demonstrated the impact of symptom reference ranges on prevalence estimates (Guan et al., 2023). Population-based and clinical-research cohorts have also not been separately evaluated, impacting the robustness of pooled prevalence estimates given potential recruitment and sampling biases (Hoy et al., 2012), and new studies have been published, with increased use of ISTAART criteria, improving measurement accuracy. Accurate characterisation of MBI prevalence is therefore important for understanding the frequency of this emerging risk state, informing early identification, and interpreting the potential utility of MBI as a marker of neurodegenerative risk.

MBI has been identified across non-dementia populations and prevalence estimates increase as cognitive impairment worsens. However, estimates vary substantially according to recruitment setting, cognitive status, and MBI measurement approaches. Prevalence in CN individuals were estimated as 17% compared to 45.5% in MCI (Pan et al., 2020). Individuals with SCD or CN individuals defined as ‘at-risk’ for dementia progression (CN-AR) fell in-between these

estimates, with a prevalence of 35.8% reported by Pan and colleagues (2020). At the domain-level, prevalence estimates were lower for CN and higher for MCI individuals.

To the best of our knowledge, this is the first review to integrate prevalence and dementia risk outcomes across clinically meaningful cognitive groups, particularly at the MBI domain-level. Longitudinal studies have demonstrated associations between MBI and accelerated cognitive decline (Creese et al., 2019; Ismail et al., 2021) and dementia conversion (Ghahremani et al., 2023; Guan et al., 2023; Sharif et al., 2025), in MCI and to a lesser extent, in CN individuals (Creese et al., 2019; Jin et al., 2023). Higher dementia progression rates compared to cognitive impairment alone, or psychiatric diagnoses, have also been suggested (Taragano et al., 2018). As MBI is a heterogenous syndrome, and individual domains appear to differ in frequency and prognostic associations with dementia, domain-specific evaluations may provide further insight into the clinical relevance of MBI compared to consideration of the syndrome as a single construct (Jin et al., 2023; Pan et al., 2021). Emerging neuropathological, biomarker, and neuroimaging studies support associations between MBI and underlying neurodegenerative processes (Jin et al., 2023), however further characterisation of clinical significance within older adult clinical settings is warranted.

Objectives

This review aimed to estimate pooled prevalence of MBI domains amongst CN, SCD, and MCI individuals, and evaluate risk of progression to incident dementia associated with MBI and its specific domains. Whilst overall MBI prevalence estimates were not a primary aim, this outcome was pooled alongside studies describing domain-level frequency.

Research Questions

1: What is the estimated prevalence of each MBI domain in non-dementia populations?

2: What is the association between (overall and domain-level) MBI and incident dementia?

## Methods

This systematic review and meta-analysis were conducted by following the updated PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analysis) guidelines (Page et al., 2021; Appendix A1). The protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO: CRD420251247550).

### Search Strategy, Screening and Study Selection

An initial search for literature published between 1 January 2012 to 30 September 2025 was conducted using PubMed, PsycINFO, and Scopus databases. This was updated on 30 April 2026, and one additional study was identified. Search terms were kept broad (Appendix A2), as MBI remains a relatively new concept. The search was conducted from 2012 to capture the earliest operationalisation of the ISTAART-MBI criteria whilst limiting searches from initial conceptualisations of MBI, framed as prodromal to FTD rather than all-cause dementia (Ismail et al., 2016). Search results were managed manually by the researcher. After removing duplicates, studies were assessed by title and abstract against the eligibility criteria, and remaining articles by examining the full text. The researcher searched and screened all retrieved studies independently. A second reviewer independently screened a random 20% of articles at the title/abstract stage, and a random 50% of articles at the full-text stage. No discrepancies were noted between the researcher and second reviewer.

### Eligibility Criteria

The inclusion criteria were as follows: (1) older adult participants aged ≥50 years, with no known dementia at the time of MBI assessment; (2) recruited from any cohort study design including community, clinical, and research settings; (3) MBI assessed with MBI-C, or NPI/NPI-Q mapped onto ISTAART-MBI domains; (4) study reports prevalence of MBI domains and/or risk of MBI (overall or domain-level) progression to incident dementia; (5) study utilises an observational design (i.e., cross-sectional for prevalence outcomes, longitudinal for incident risk); and (6) articles published in English. Studies were excluded if they met one of the following exclusion criteria: (1) NPI/NPI-Q used without mapping onto ISTAART-MBI, or studies utilising a different measure to approximate MBI; (2) report overall prevalence only without domain-level prevalence or risk effect sizes; (3) and case reports, reviews, editorials, and grey literature sources. The latter was excluded to maintain a well-

defined and reproducible evidence base, focused on peer-reviewed observational research with clearly reported methodology and outcomes.

Of note, the ISTAART-MBI criteria requires symptoms to persist for at least six-months (Ismail et al., 2016), whilst the NPI/NPI-Q measures symptoms across one-month (Cummings et al., 1997). As the algorithm mapping items from the NPI to MBI domains is commonly utilised (Mortby et al., 2018; Sheikh et al., 2018), this was included in the review. Meta-analyses completed were specific to studies meeting persistence, however, consistent with ISTAART. A supplementary analysis provided additional results when including estimates measured across one-month. Although study participants did not have dementia, SCD and MCI were included alongside CN individuals. A history of psychiatric or neurological conditions was not used as an exclusion criterion, as ISTAART criteria requires NPS to have newly emerged and not be explained by prior psychiatric/neurological conditions. However, studies completed in these populations were excluded to minimise the potential for false positives.

Data Extraction

Data was extracted by one reviewer (PdB) and included characteristics of studies (e.g., author(s), title, abstract, publication year, population area/country, study design, recruitment setting), participants (e.g., sample size, baseline cognitive status, age, gender distribution) and outcomes (e.g., MBI diagnostic criteria, measurement tool, cross-sectional prevalence, risk to incident dementia, duration of follow-up), where data was available.

Quality Appraisal

The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Studies Reporting Prevalence Data (Munn et al., 2020) was used to evaluate methodological quality of retrieved prevalence studies. It consists of 9 questions, with 'Yes/No/Unclear/Not Applicable' responses. JBI discourages use of a scoring system (Munn et al., 2014) and does not provide an overall quality rating (Munn et al., 2020). For longitudinal studies reporting on incident dementia risk, the Cochrane Quality in Prognosis Studies (QUIPS; Hayden et al., 2013) was used to appraise methodological quality. This allowed for risk of bias to be rated as Low, Moderate, or High across six areas of potential bias. Studies reporting prevalence and risk outcomes were evaluated by both quality appraisal tools for comprehensiveness. Studies were not excluded from the meta-analysis based on these ratings. The researcher completed quality appraisal

assessments for all included studies, and a second reviewer independently reviewed a random 50% of retrieved articles. Disagreements were minimal and resolved by brief discussions.

Statistical Analysis

Meta-analyses were undertaken where feasible. Where multiple publications reported data from the same population, only the most accurate, comprehensive, or recent publication was included to avoid double-counting participants (Higgins et al., 2024), with accuracy determined based on accordance to the ISTAART criteria. For prevalence, population-based studies were pooled as a primary meta-analysis and clinical-research-cohorts as a secondary meta-analysis, based on differing critical appraisal results. Secondary meta-analyses therefore acknowledge potential limitations in representativeness of estimated pooled prevalence given possible selection biases. Pooled prevalence estimates for MBI domains and pooled hazard ratios (HR), reflecting relative dementia rates over follow-up, with corresponding 95% confidence intervals (CI) for overall and domain-level MBI were generated using random-effects meta-analysis. Random-effects accounted for anticipated heterogeneity between studies, including differences in setting, baseline cognitive status, and MBI assessment methods. Analyses were conducted separately for CN and MCI samples to investigate cognitive status differences, whilst studies combining cognitive groups were not synthesised given the limited additional value this provides in clinical settings and not aligning with the inclusion criteria. Subgroup data was analysed where available. These studies were nevertheless retained for completeness. Meta-analysis was restricted to HRs due to insufficient availability of other effect measures. The $I^2$ statistic was used to analyse heterogeneity between studies, with values over 75% being classified as 'high' heterogeneity. The minimum number of studies required to complete a funnel plot and Egger's test to evaluate for publication bias was not met and therefore not completed, and meta-regression was not feasible (Higgins et al., 2024). Sensitivity analyses were completed where appropriate and involved leave-one-out and outlier analysis to assess the robustness of pooled estimates. R was used for all statistical analyses (Version 4.5.2). Study characteristics and outcomes were summarised in a table, and meta-analysis results presented using forest plots. Narrative synthesis was undertaken where meta-analysis was not feasible or appropriate.

## Results

The PRISMA (2020) flow diagram of identifying and screening studies is depicted in Figure 2. The literature search yielded 2408 citations. 234 duplicates were identified and removed. Screening titles and abstracts removed 2113 irrelevant studies or those not meeting the pre-specified eligibility criteria. The remaining 61 studies were taken to full-text review; of these, 25 reports met criteria for inclusion in the systematic review. Characteristics of included studies and extracted outcomes are shown in Table 3. Where sufficient studies (≥2) with independent participants and matched cognitive status was identified, meta-analysis was completed. Using strict ISTAART criteria, six datasets were pooled across prevalence and risk data, whilst a supplementary analysis of both one-month and ≥six-month symptoms included 12 datasets. One study using the MBI-C was included in meta-analyses regardless of the differing measurement tool. 12 studies were not included in synthesis of results as outcomes were measured in combined clinical groups (e.g., CN, SCD, and MCI). Summarised quality appraisal results are presented in Table 4 for prevalence and Table 5 for risk, with further detail provided in Appendix A3 and A4, respectively.

For risk studies, a HR>1 indicates a higher hazard of the specified outcome among individuals with MBI compared to those without NPS, whereas an HR<1 would indicate a lower hazard. The HR reflects the relative rate of experiencing the specified outcome over the follow-up period rather than the absolute probability of developing dementia. Domain-specific HRs compared participants with and without each individual MBI domain.

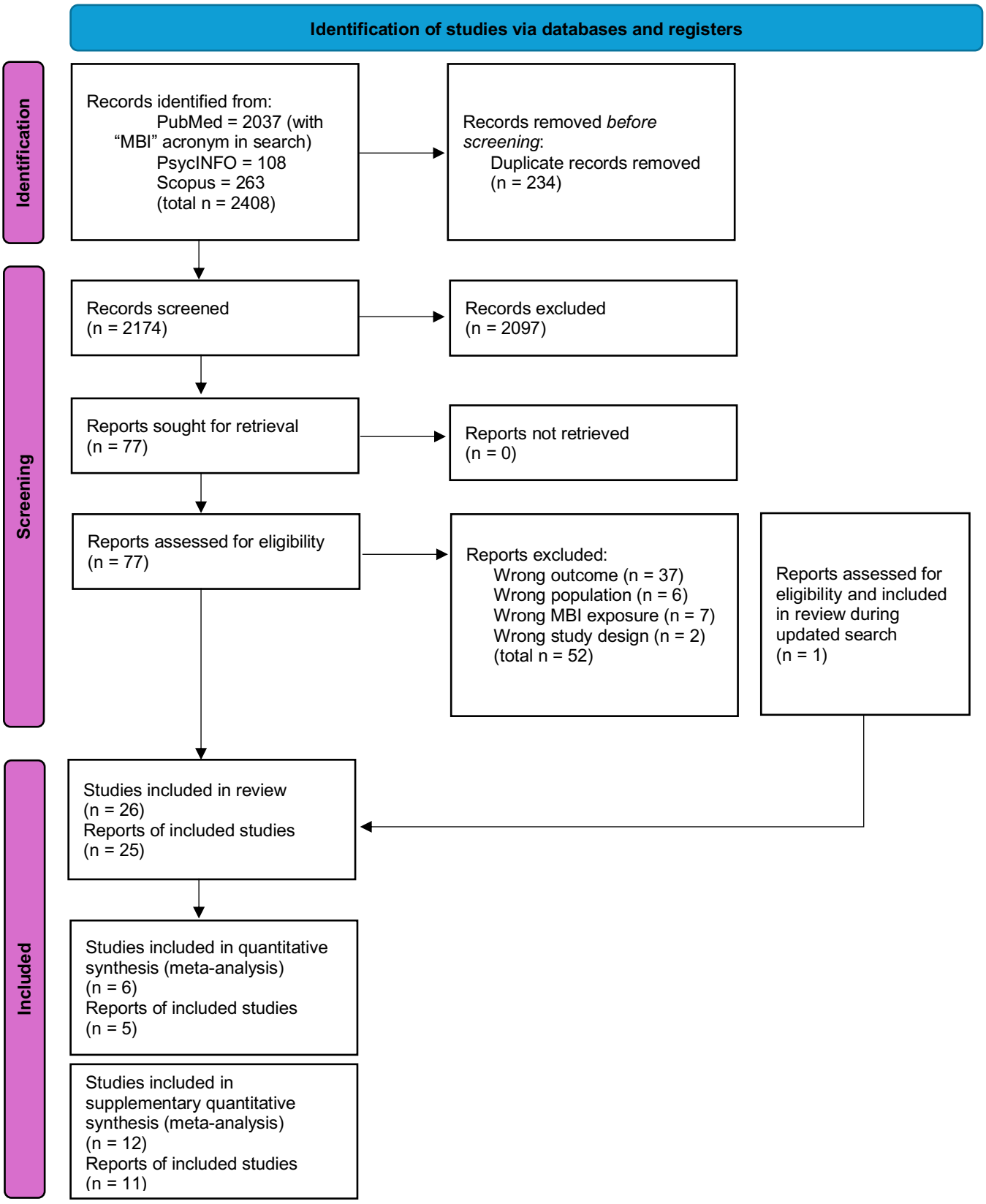



*Figure 2: PRISMA Flow Diagram.*

*Table 3: Study Characteristics and Extracted Outcomes*

| First Author, Publication Year | Population Area | Participant Cognitive Status, Sample Size (N) | Recruitment Centre/ Database, Cohort Type | Study Design | Mean Age (Year, (SD)) | Percentage of Females | MBI Criteria, Assessment Tool | MBI+ Prevalence, Domain Prevalence (%) | MBI+ Risk to dementia, Domain Risk (Adjusted HR, 95% CI) |
|---|---|---|---|---|---|---|---|---|---|
| **Studies included in meta-analyses:** | | | | | | | | | |
| De Lucia et al., 2025 | United States and Canada | CN (N=418)<br><br>aMCI (N=232) | ADNI-3 (Mar-May 2025)<br><br>Multi-centre clinic-based research cohort | Cross-sectional | CN+MBI =81.82 (5.99)<br>CN+NoMBI =79.79 (7.52)<br><br>aMCI+MBI =82.04 (7.67)<br>aMCI+NoMBI =81.01 (8.68) | CN=59%<br><br>aMCI=44% | ISTAART<br><br>Persistence=2 consecutive annual visits<br><br>NPI-Q | CN=<br>MBI=19.6%<br>AFD=13.1%<br>IDS=10.2%<br>DMT=3.5%<br>SIP=0.9%<br>APT=0%<br><br>aMCI=<br>MBI=53.5%<br>AFD=34.4%<br>IDS=30.6%<br>DMT=15.9%<br>SIP=12%<br>APT=1.2% | N/A |
| Matsuoka et al., 2021 | Japan | CN (N=30)<br><br>aMCI (N=13) | Centre for Diagnosis of Dementia, Kyoto Prefectural University of Medicine<br><br>Clinic-based research cohort | Cross-sectional | CN=76.1 (5.7)<br><br>aMCI=78.8 (5.4) | CN=60%<br><br>aMCI=38% | ISTAART<br><br>6-month range<br><br>MBI-C (cut-off of 6.5) | CN=<br>MBI=63%<br>AFD=43%<br>IDS=43%<br>DMT=23%<br>SIP=6.7%<br>APT=3.3%<br><br>aMCI=<br>MBI=77%<br>AFD=46%<br>IDS=31%<br>DMT=54%<br>SIP=15% | N/A |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | APT=0% | |
| Guan et al., 2024 | United States | CN (N=923)<br><br>MCI (N=350) | NACC (Jun 2005-Feb 2022)<br><br>Multi-centre clinic-based research cohort | Longitudinal | CN=68.3 (10)<br><br>MCI=73.6 (8) | CN=65.2%<br><br>MCI=47.4% | ISTAART<br><br>Persistence=two-thirds of annual visits<br><br>NPI-Q | CN=<br>MBI=4.9%<br>AFD=3.5%<br>IDS=3.7%<br>DMT=1.3%<br>SIP=0.9%<br>APT=0.3%<br><br>MCI=<br>MBI=29.1%<br>AFD=20%<br>IDS=18.9%<br>DMT=10.6%<br>SIP=6.6%<br>APT=1.7% | CN-to-MCI/Dementia =2.73HR (1.72-4.31)<br><br>MCI-to-Dementia =2.50HR (1.72-3.63) |
| Ismail, Leon et al., 2023 | United States and Canada | MCI (N=352) | ADNI (2003-2021)<br><br>Multi-centre clinic-based research cohort | Longitudinal | MCI=71.68 (7.40) | MCI=43.5% | ISTAART<br><br>Persistence=2 consecutive annual visits<br><br>NPI/NPI-Q | MCI=<br>MBI=26.42% | MCI-to-Dementia=3.5HR (1.99-6.17) |
| Ismail, Leon et al., 2023 | France | MCI (N=158) | MEMENTO (Apr 2011-Jun 2014)<br><br>Multi-centre clinic-based research cohort | Longitudinal | MCI=68.98 (8.18) | MCI=46.2% | ISTAART<br><br>Persistence=2 consecutive annual visits<br><br>NPI/NPI-Q | MCI=<br>MBI=45.57% | MCI-to-Dementia=3.93HR (1.53-10.07) |
| **Studies included in narrative synthesis:** | | | | | | | | | |
| Mortby et al., 2018 | Australia | CN (N=847) | PATH Wave4 (2001-2013) | Longitudinal | CN=74.9 (1.5) | CN=48.4%<br><br>CN-AR=49.1% | ISTAART*<br>1-month range (no persistence) | CN=<br>MBI=27.6%<br>AFD=17.2% | N/A |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | CN-AR (N=397)<br><br>MCI (N=133) | Population-based, community cohort, randomly recruited via electoral roll | | CN-AR=75.2 (1.6)<br><br>MCI=75.2 (1.6) | MCI=42.1% | NPI | IDS=16.3%<br>DMT=3.1%<br>SIP=4.7%<br>APT=0.9%<br><br>CN-AR=<br>MBI=43.1%<br>AFD=26.2%<br>IDS=28.7%<br>DMT=8.3%<br>SIP=7.1%<br>APT=2.8%<br><br>MCI=<br>MBI=48.9%<br>AFD=32.3%<br>IDS=33.8%<br>DMT=9%<br>SIP=3.8%<br>APT=1.5% | |
| Vassilaki et al., 2023 | United States | CN (N=2498)<br><br>MCI (N=215) | MCSA<br><br>Population-based, community cohort, randomly recruited via Rochester Epidemiology Project | Cross-sectional | CN=74.06 (9.48) | CN=47% | ISTAART* 1-month range (no persistence)<br><br>NPI-Q | CN=<br>MBI=10%<br>AFD=6%<br>IDS=4.4%<br>DMT=2%<br>SIP=0.3%<br>APT=0%<br><br>MCI=<br>MBI=29% | N/A |
| Andrews et al., 2018 | Australia | CN (N=763)<br><br>CN-AR (N=352) | PATH Wave4 (2014-2015)<br><br>Population-based, | Cross-sectional | CN=74.93 (1.45)<br><br>CN-AR=75.2 (1.59) | CN=47.48%<br><br>CN-AR =49.72% | ISTAART* 1-month range (no persistence)<br><br>NPI | CN=<br>AFD=17.04%<br>IDS=15.47%<br>DMT=3.01%<br>SIP=4.85% | N/A |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | MCI (N=111) | community cohort, randomly recruited via electoral roll | | MCI=75.14 (1.66) | MCI= 42.34% | | APT=1.05%<br><br>CN-AR=<br>AFD=26.14%<br>IDS=28.69%<br>DMT=8.52%<br>SIP=6.82%<br>APT=2.84%<br><br>MCI=<br>AFD=33.33%<br>IDS=32.43%<br>DMT=9.91%<br>SIP=3.6%<br>APT=1.8% | |
| Sheikh et al., 2018 | Canada | SCD (N=119)<br><br>MCI (N=163) | PROMPT<br><br>Clinic-based cohort (consecutive memory clinics, Jan 2010-Sept 2015) | Cross-sectional | Median=<br>SCD=59<br><br>MCI=64 | SCD=56.3%<br><br>MCI=42.3% | ISTAART*<br>1-month range (no persistence)<br><br>NPI-Q | SCD=<br>MBI=76.5%<br>AFD=56.3%<br>IDS=47.9%<br>DMT=32.8%<br>SIP=21.8%<br>APT=4.2%<br><br>MCI=<br>MBI=85.3%<br>AFD=68.7%<br>IDS=55.8%<br>DMT=49.1%<br>SIP=23.3%<br>APT=9.2% | N/A |
| Yokoi et al., 2019 | Japan | MCI (N=234) | J-ADNI (2008-2013)<br><br>Multi-centre clinic-based | Longitudinal | MCI=72.79 (5.88) | MCI=50.4% | ISTAART*<br>1-month range (no persistence) | MCI=<br>MBI=49.6%<br>AFD=37.9%<br>IDS=20.7%<br>DMT=18.5%<br>SIP=2.6% | MCI-to-Dementia=1.13 HR(Unadjusted)<br><br>AFD=0.75HR (0.50-1.14)<br>IDS=0.96HR (0.60-1.55)<br>DMT=1.27HR(0.79-2.04) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | research cohort | | | | Includes appetite/eating items in IDS<br><br>NPI-Q | APT=3.0% | SIP=1.93 (0.69-5.45)<br>APT=2.71HR (1.13-6.50) |
| Yoon et al., 2023 | South Korea | aMCI (N=1184) | SMG-SNU Boramae Medical Centre/Dongjak Gu Center for Dementia (2012-2020)<br><br>Clinic-based research cohort | Longitudinal | aMCI=73.5 (5.7) | aMCI=61.74% | ISTAART* 1-month range (no persistence)<br><br>NPI-Q by clinical psychologists based on informant interviews | MCI=<br>MBI=52.6%<br>AFD=47.3%<br>IDS=14.2%<br>DMT=12.7%<br>SIP=4.4%<br>APT=4.4% | aMCI-to-AD=1.78HR (1.37-2.33)<br><br>AFD=1.37HR (1.05-1.80)<br>IDS=1.92HR (1.44-2.55)<br>DMT=2.13HR (1.56-2.85)<br>SIP=1.60HR (1.01-2.54)<br>APT=2.26HR (1.50-3.40) |
| Gill et al., 2021 | United States and Canada | CN (N=70)<br><br>MCI (N=95) | ADNI-GO/2<br><br>Multi-centre clinic-based research cohort | Cross-sectional | N/A | N/A | ISTAART* 1-month range (no persistence)<br><br>NPI-Q | CN=<br>IDS=17%<br><br>MCI=<br>IDS=43% | N/A |
| Ruthirakuhan et al., 2022 | United States | CN (N=11372) | NACC (Aug 2005-Dec 2020)<br><br>Multi-centre clinic-based research cohort | Longitudinal | MBI=70.1 (10.3)<br><br>NoMBI=70.6 (10.4) | MBI=60%<br><br>NoMBI=67% | ISTAART* 1-month range (no persistence)<br><br>NPI-Q | CN=<br>MBI=24% | CN-to-AD=1.75HR (1.56-1.96)<br><br>AFD=1.35HR (1.18-1.54)<br>IDS=2.01HR (1.75-2.32)<br>DMT=1.77HR (1.47-2.14)<br>SIP=2.25HR (1.67-3.03)<br>APT=6.49(4.51-9.34)<br><br>CN-to-Neuropathology-Confirmed-AD=1.59HR (1.07-2.37) |

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|---|---|---|---|---|---|---|---|---|---|
| Park et al., 2024 | United States and Canada | CN (N=868)<br><br>MCI (N=1066) | ADNI<br><br>Multi-centre clinic-based research cohort | Cross-sectional | CN=72.48 (6.62)<br><br>MCI=72.80 (7.58) | CN=56.2%<br><br>MCI=41.2% | ISTAART*<br>1-month range (no persistence)<br><br>NPI/NPI-Q | CN=<br>MBI=16.1%<br>AFD=9.9%<br>IDS=9.3%<br>DMT=2.5%<br>SIP=0.9%<br>APT=0.1%<br><br>MCI=<br>MBI=52.7%<br>AFD=34.1%<br>IDS=33.9%<br>DMT=15.6%<br>SIP=9.1%<br>APT=1.9% | N/A |
| **Studied included in systematic review however not synthesised (due to combining cognitive groups, or non-HR effect-sizes):** | | | | | | | | | |
| Kan et al., 2022 | Singapore | CN+CIND-Mild+CIND-Moderate (N=304) | Clinic and community-based research cohort (Aug 2010-Oct 2019) | Longitudinal | CN+CIND-Mild+CIND-Moderate =72.2 (8) | CN+CIND-Mild+CIND-Moderate= 51.6% | ISTAART<br><br>Persistence=2 consecutive annual visits<br><br>NPI | CN+CIND=<br>MBI=14.5%<br><br>CN=<br>MBI=7.1% | CN+CIND-to-Dementia=2.53HR (1.14-5.65) |
| Guan et al., 2022 | Canada | CN+SCD+ MCI (N=193) | COMPASS-ND (Feb 2020 release)<br><br>Multi-centre clinic and community-based research cohort | Cross-sectional | CN+SCD =69.7 (6.5) | CN+SCD= 82.8% | ISTAART*<br>1-month range (no persistence)<br><br>NPI-Q | CN+SCD+MCI=<br>MBI=46.6%<br>AFD=32.1%<br>IDS=29.5%<br>DMT=12.4%<br>SIP=13.5%<br>APT=4.15% | N/A |
| Ebrahim et al., 2023 | United States | CN+MCI<br><br>MBI-AFD (N=1286) | NACC (Dec 2021 freeze) | Longitudinal | CN+MCI+ AFD=75 (9.57) | CN+MCI+AFD =54.5%<br><br>CN+MCI+ | ISTAART | CN+MCI=<br>AFD=25.8% | CN+MCI+AFD-to-Dementia=1.76HR (1.48-2.08) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | NoNPS (N=3698) | Multi-centre clinic-based research cohort | | CN+MCI+ NoNPS=72.8 (9.8) | NoNPS= 62.7% | Persistence=2 consecutive annual visits<br><br>NPI-Q | | |
| Ghahremani et al., 2025 | United States | CN+SCD (N=12111)<br><br>SCD (N=3485) | NACC (Mar 2022 freeze)<br><br>Multi-centre clinic-based research cohort | Longitudinal | NoNPS=71.2 (8.9)<br><br>NPS-not-MBI=71.6. (8.8)<br><br>MBI=75.2 (9.5) | NoNPS= 67.6%<br><br>NPS-not-MBI=65.5%<br><br>MBI=54.3% | ISTAART<br><br>Persistence=two-thirds of study visits<br><br>NPI-Q | N/A | CN+SCD-to-Dementia=2.76HR (2.27-3.35)<br><br>AFD=2.93HR (2.31-3.72)<br>IDS=3.08HR (2.42-3.93)<br>DMT=6.47HR (4.66-8.97)<br>SIP=7.86HR (5.33-11.60)<br>APT=15.80HR (8.43-29.63)<br><br>SCD-to-Dementia=1.99HR (1.46-2.71) |
| Ismail et al., 2021 | United States | MBI-SCD- (N = 1536)<br><br>MBI-SCD+ (N = 254)<br><br>MBI+SCD- (N = 743)<br><br>MBI+SCD+ (N = 236) | NACC (Dec 2018 freeze)<br><br>Multi-centre clinic-based research cohort | Longitudinal | MBI-SCD- =72.07 (9.22)<br><br>MBI-SCD+ =74.80 (8.88)<br><br>MBI+SCD- =73.46 (9.11)<br><br>MBI+SCD+ =74.30 (9.53) | MBI-SCD- =68%<br><br>MBI-SCD+ =63%<br><br>MBI+SCD- =54.1%<br><br>MBI+SCD+ =62.3% | ISTAART<br><br>Persistence=2 consecutive annual visits<br><br>NPI-Q | N/A | Adjusted OR (95% CI)=<br><br>+SCD-to-Dementia= 9.33AOR (1.53–56.78)<br><br>-SCD-to-Dementia=19.23AOR (4.40–84.03) |
| McGirr et al., 2022 | United States | MCI<br><br>NoNPS (N=409)<br><br>NPS-not-MBI | NACC (Nov 2020 freeze)<br><br>Multi-centre clinic-based research cohort | Longitudinal | NoNPS=76 (8.2)<br><br>NPS-not-MBI =76.5 (7.9) | NoNPS= 49.6%<br><br>NPS-not-MBI =45.9% | ISTAART<br><br>Persistence=2 consecutive annual visits | N/A | Adjusted OR (95% CI)=<br><br>MCI-to-Dementia=2.10AOR (1.47-2.99) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | (N=331)<br><br>MBI (N=330) | | | MBI=74 (8.8) | MBI=50.8% | NPI-Q | | |
| Ghahremani et al., 2023 | United States and Canada | CN+MCI (N=571) | ADNI<br><br>Multi-centre clinic-based research cohort | Longitudinal | NoNPS=72.2 (7.03)<br><br>NPS-not-MBI =72.2 (7.14)<br><br>MBI=72.1 (7.25) | NoNPS= 52.3%<br><br>NPS-not-MBI =48.9%<br><br>MBI=26.2% | ISTAART<br><br>Persistence=2 annual visits<br><br>NPI/NPI-Q | CN+MCI= MBI=18.04% | CN+MCI-to-Dementia=3.92HR (2.27-6.79) |
| Sharif et al., 2025 | United States | CN+MCI (N=1016)<br><br>NoNPS (N=533)<br><br>MBI (N=195)<br><br>NPS-not-MBI (N=288) | NACC (May 2022 freeze)<br><br>Multi-centre clinic-based research cohort | Longitudinal | NoNPS=83.93 (8.37)<br><br>NPSnoMBI= 81.31 (8.78)<br><br>MBI=81.08 (10.06) | NoNPS= 52.2%<br><br>NPS-not-MBI=48.3%<br><br>MBI=40% | ISTAART<br><br>Persistence=two-thirds of study visits<br><br>NPI-Q | CN+MCI= MBI=19.19% | CN+MCI-to-AD=2.03HR (1.60-2.57) |
| Ismail, Ghahremani et al., 2023 | United States | CN+MCI (N=3770)<br><br>NoNPS (N=3704)<br><br>MBI-APT (N=66) | NACC (Dec 2021 freeze)<br><br>Multi-centre clinic-based research cohort | Longitudinal | NoNPS=72.8 (9.9)<br><br>MBI-APT =75.2 (9.8) | NoNPS= 62.7%<br><br>MBI-APT =53% | ISTAART<br><br>Persistence=2 consecutive visits<br><br>NPI-Q | N/A | APT-to-Dementia=3.76HR (2.53-5.58) |
| Guan et al., 2023 | United States | CN+SCD +MCI (N=13703) | NACC (2005-2022) | Longitudinal | MBI=73.2(9) | MBI=57.6% | ISTAART | CN+SCD+MCI= MBI=32.3% AFD=20% IDS=20% | CN+SCD+MCI-to-Dementia=2.13HR (1.96-2.32) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Multi-centre clinic-based research cohort | | | | Persistence=2 consecutive annual visits<br><br>NPI-Q | DMT=7.8%<br>SIP=4.5%<br>APT=1.8% | NoPersistenceMBI-to-Dementia=1.48HR (1.35-1.62)<br><br>>two-third-of-visits-PersistenceMBI-to-Dementia=2.97HR (2.72-3.25) |
| Gosselin et al., 2023 | United States | CN+SCD+ MCI (N=7080) | NACC (2005-2022)<br><br>Multi-centre clinic-based research cohort | Cross-sectional | CN+SCD+ MCI=71.6 (8.8) | CN+SCD+MCI =61.7% | ISTAART<br><br>Persistence=2 consecutive visits<br><br>NPI-Q | CN+SCD+MCI=<br>MBI=16.8%<br>AFD=10.6%<br>IDS=10.9%<br>DMT=4.2%<br>SIP=2.4%<br>APT=0.9% | N/A |
| Guan, Rockwell et al., 2022 | Canada | CN+SCD+ MCI (N=219) | COMPASS-ND<br><br>Multi-centre clinic and community-based research cohort | Cross-sectional | CN+SCD+ MCI=72.2 (6.5) | N/A | ISTAART*<br>1-month range (no persistence)<br><br>NPI-Q | CN+SCD+MCI=<br>MBI=51.6%<br>AFD=35.5%<br>IDS=32.7%<br>DMT=16.1%<br>SIP=12.9%<br>APT=6.9% | N/A |

CN, cognitively normal; CN-AR, cognitively-normal-but-at-risk; MCI, mild cognitive impairment; aMCI, amnestic mild cognitive impairment; CIND, cognitive-impairment-not-dementia; ISTAART, International Society to Advance Alzheimer's Research and Treatment; MBI, mild behavioural impairment; AFD, affective dysregulation; IDS, impulse dyscontrol; DMT, decreased motivation; SIP, social inappropriateness; APT, abnormal perception/thought; NPS, neuropsychiatric symptoms; NPI, Neuropsychiatric Inventory; NPI-Q, Neuropsychiatric Inventory Questionnaire; MBI-C, mild behavioural impairment checklist; HR, hazard ratio; CI, confidence interval; AOR, adjusted odds ratio; NA not available; NACC, National Alzheimer's Coordinating Centre; ADNI, Alzheimer's Disease Neuroimaging Initiative; J-ADNI, Japanese-Alzheimer's Disease Neuroimaging Initiative; COMPASS-ND, Comprehensive Assessment of Neurodegeneration and Dementia; PATH, Personality and Total Health Through Life; MCSA, Mayo Clinic Study of Aging

*Table 4: JBI Critical Appraisal Checklist for Prevalence Data Summary*

| **JBI Item Responses** | **Yes** | **No** | **Unclear** | **N/A** |
|---|---|---|---|---|
| **First Author, Publication Year** | | | | |
| Mortby et al., 2018 | 6 | 0 | 3 | 0 |
| Guan et al., 2022 | 3 | 1 | 5 | 0 |
| Park et al., 2024 | 3 | 1 | 5 | 0 |
| De Lucia et al., 2025 | 3 | 1 | 5 | 0 |
| Sheilkh et al., 2018 | 4 | 1 | 4 | 0 |
| Gill et al., 2021 | 3 | 1 | 5 | 0 |
| Yokoi et al., 2019 | 3 | 1 | 5 | 0 |
| Yoon et al., 2023 | 4 | 1 | 4 | 0 |
| Guan et al., 2024 | 3 | 1 | 5 | 0 |
| Vassilaki et al., 2026 | 6 | 0 | 3 | 0 |
| Gosselin et al., 2023 | 3 | 1 | 5 | 0 |
| Guan, Rockwood et al., 2022 | 4 | 1 | 4 | 0 |
| Matsuoka et al., 2021 | 4 | 1 | 4 | 0 |
| Andrews et al., 2018 | 6 | 0 | 3 | 0 |

*Table 5: QUIPS Critical Appraisal Tool for Risk Data – Risk of Bias Ratings Summary*

| **QUIPS Items**<br>**First Author, Publication Year** | **1: Study Participation** | **2: Study Attrition** | **3: Prognostic Factor Measurement** | **4: Outcome Measurement** | **5: Study Confounding** | **6: Statistical Analysis and Reporting** |
|---|---|---|---|---|---|---|
| Yoon et al., 2023 | Moderate | Moderate | Low | Low | Low | Low |
| Guan et al., 2024 | Moderate | Moderate | Low | Low | Low | Low |
| Ghahremani et al., 2025 | Moderate | Moderate | Low | Low | Low | Low |
| Kan et al., 2022 | Moderate | Moderate | Low | Low | Low | Low |
| Yokoi et al., 2019 | Moderate | Moderate | High | Low | Moderate | Low |
| Ruthirakuhan et al., 2022 | Moderate | Moderate | Low | Low | Low | Low |
| Ghahremani et al., 2023 | Moderate | Moderate | Low | Low | Low | Low |
| Ismail, Leon et al., 2023 | Moderate | Moderate | Low | Low | Low | Low |
| Ismail et al., 2021 | Moderate | Moderate | Low | Low | Low | Low |
| McGirr et al., 2022 | Moderate | Moderate | Low | Low | Low | Low |
| Ismail, Ghahremani et al., 2023 | Moderate | Moderate | Low | Low | Low | Low |
| Ebrahim et al., 2023 | Moderate | Moderate | Low | Low | Low | Low |
| Sharif et al., 2025 | Moderate | Moderate | Low | Low | Low | Low |
| Guan et al., 2023 | Moderate | Moderate | Low | Low | Low | Low |

MBI Domain Prevalence in CN Individuals

Three population-based studies (Andrews et al., 2018; Mortby et al., 2018; Vassilaki et al., 2026) described MBI prevalence in CN individuals. Two studies were derived from the same PATH cohort and reported near-identical prevalence rates, whilst Vassilaki and colleagues (2026) reported on the MCSA cohort. Studies were narratively synthesised as MBI was ascertained across one-month. MBI prevalence ranged from 11.00-27.60%, with significant variation likely attributable to the MCSA cohort excluding NPS at baseline, resulting in lower estimates. Domain-level prevalence ranged between 6.80-17.20% for affective dysregulation, 5.30-16.30% for impulse dyscontrol, 2.30-3.10% for decreased motivation, 0.50-4.90% for social inappropriateness, and 0.30-1.10% for abnormal perception/thought. Although estimates varied, the overall pattern of frequency was largely consistent, except for social inappropriateness and decreased motivation in Andrews and colleagues (2018).

A secondary meta-analysis was completed with four clinic-based research cohorts for overall prevalence, and three for domain-level. Results are presented as forest plots in Figure 3. Pooled MBI prevalence (De Lucia et al., 2025, Guan et al., 2024, Kan et al., 2022; Matsuoka et al., 2021, N=1470) was estimated as 9.09% (95% CI 3.18-23.37%, $I^2$=95.4%), whilst meta-analysis pooling domain prevalence (De Lucia et al., 2025, Guan et al., 2024, Matsuoka et al., 2021; N=1371) estimated 13.31% (95% CI 0.71-76.65%) for affective dysregulation, 12.45% (95% CI 0.69-74.49%) for impulse dyscontrol, 4.66% (95% CI 0.20-53.81%) for decreased motivation, 1.02% (95% CI 0.32-3.17%) for social inappropriateness, and 0.29% (95% CI 0.03-2.46%) for abnormal perception/thought, with a similar frequency pattern as population-based studies. Considerable heterogeneity was found across domains ($I^2 \geq$71.1%), except for abnormal perception/thought, which indicated moderate heterogeneity ($I^2$=50.8%, $p$ = .1311). Sensitivity analyses (i.e., leave-one-out and outlier) for overall prevalence indicated generally robust and comparable estimates. De Lucia et al. (2025) and Guan et al. (2024) were identified as potential outliers and exclusion of these studies modestly reduced prevalence and heterogeneity, although interpretation was limited by the small number of studies available. Sensitivity analyses across domains also demonstrated generally robust prevalence estimates. Exclusion of individual studies produced modest changes in estimates and did not alter interpretation of findings. High heterogeneity remained, suggesting that between-study variability was not attributable to any single study. Outlier analyses most frequently identified

Guan et al. (2024) and Matsuoka et al. (2021) as potentially influential studies, however excluding these resulted in comparable estimates and high heterogeneity persisted.

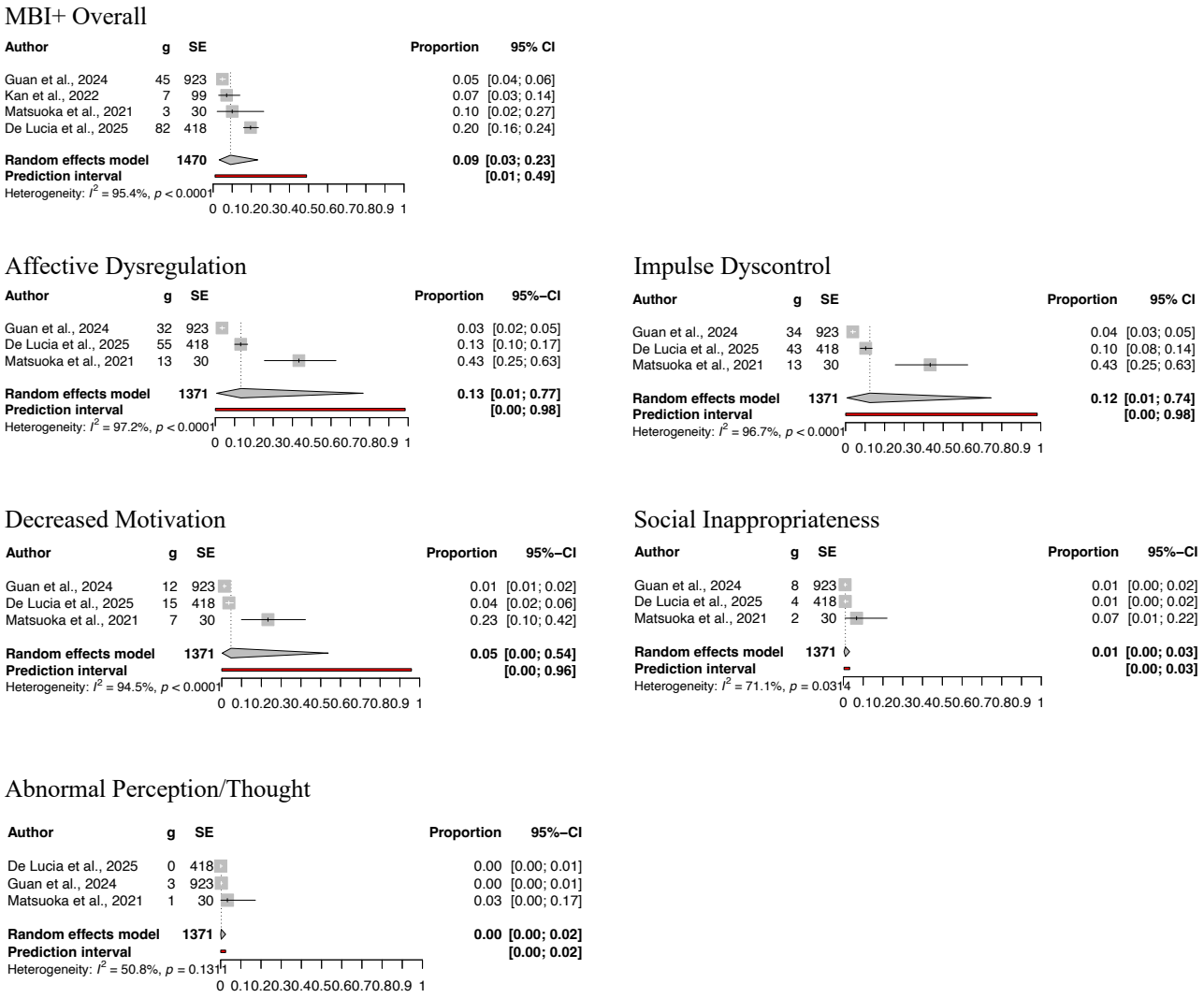



*Figure 3: Forest Plots of MBI Overall and Domain-level Estimated Pooled Prevalence in CN Individuals (Secondary Meta-Analysis)*

Two additional studies were narratively synthesised for CN individuals. A clinic-based study (Park et al., 2025) was excluded from the above meta-analysis due to overlapping datasets from the ADNI-3 cohort and measuring MBI across one-month. Overall MBI prevalence was higher in this sample of CN individuals compared to the pooled meta-analysis (16.10%), however domain-level prevalence estimates were slightly lower (9.90%-affective dysregulation, 9.30%-impulse dyscontrol, 2.50%-decreased motivation, 0.90%-social inappropriateness, 0.10%-abnormal perception/thought). Nevertheless, the frequency pattern of domains was consistent. Another study investigating impulse dyscontrol (Gill et al., 2021) was excluded due to lack of

persistence. A higher prevalence (17%) was reported, although this remains within the confidence interval of pooled estimates, and is broadly comparable with population-based studies. The latter study supports the secondary meta-analysis finding of impulse dyscontrol being a relatively frequent MBI domain.

Supplementary meta-analyses were completed across population-based and secondary-cohort studies to pool estimates from non-persistent and persistent MBI symptoms (Appendix A5), with largely comparable results to the above narrative synthesis and minimal impact on pooled prevalence of the secondary meta-analysis.

MBI Domain Prevalence in SCD Individuals

Two population-based studies (Andrews et al., 2018; Mortby et al., 2018) from the same dataset reported MBI prevalence to be 43.10% in CN-AR individuals, and domain-level prevalence was reported as: 26.20%-affective dysregulation, 28.70%-impulse dyscontrol, 8.30-8.50%-decreased motivation, 6.80-7.10%-social inappropriateness, and 2.80%-abnormal perception/thought. A memory-clinic cohort (Sheikh et al., 2018) found considerably higher prevalence in SCD individuals, with overall MBI prevalence reported as 76.50%, and domain prevalence as: 56.30%-affective dysregulation, 47.90%-impulse dyscontrol, 32.80%-decreased motivation, 21.80%-social inappropriateness, and 4.20%-abnormal perception/thought. Despite marked variation in absolute rates, the prevalence pattern of domains was largely consistent with CN individuals, except for impulse dyscontrol, which was higher in CN-AR individuals in the community.

MBI Domain Prevalence in MCI Individuals

Two population-based studies (Mortby et al., 2018; Vassilaki et al., 2026) reported on MBI prevalence in MCI individuals, ranging from 29.00-48.90%. Domain-level prevalence was reported in two studies from the same dataset (Andrews et al., 2018; Mortby et al., 2018), ranging from 32.30-33.30% for affective dysregulation, 32.40-33.80% for impulse dyscontrol, 9.00-9.90% for decreased motivation, 3.60-3.80% for social inappropriateness, and 1.50-1.80% for abnormal perception/thought. Pattern of most-to-least frequent domains remained consistent.

A secondary meta-analysis of two multi-centre clinical-research cohorts (De Lucia et al., 2025; Guan et al., 2024) and one smaller, single-centre clinical-research study (Matsuoka et al., 2021)

was completed for MCI individuals. Forest plots are presented in Figure 4. Overall MBI prevalence also pooled data from one additional study (Ismail, Leon et al., 2023, Memento) and was estimated as 38.50% (95% CI 20.42-60.42%, $I^2$=92.3%). Pooled prevalence of each MBI domain was estimated as 29.02% (95% CI 11.21-56.97%) for affect dysregulation, 24.67% (95% CI 11.69-44.77%) for impulse dyscontrol, 20.20% (95% CI 2.64-70.28%) for decreased motivation, 9.20% (95% CI 3.64-21.40%) for social inappropriateness, and 1.51% (95% CI 0.36-6.12%) for abnormal perception/thought, again demonstrating the same domain-level frequency pattern. Abnormal perception/thought showed no heterogeneity ($I^2$=0%, $p$ = .9224), whilst heterogeneity across remaining domains was substantial-to-considerable ($I^2$ ≥64.9%). For overall prevalence, the sensitivity analyses demonstrated generally robust estimates. Outlier analysis identified De Lucia et al. (2025) and Guan et al. (2024) as potentially influential studies however exclusion of outliers resulted in a comparable prevalence estimate of 31.90%, and heterogeneity reduced to 73.6%. The domain-level sensitivity analyses continued to demonstrate robust prevalence estimates. Sequential exclusion of individual studies produced modest changes in prevalence and did not alter the overall frequency pattern. Outlier analyses identified all three studies as potentially influential depending on individual domains, however no outliers were identified for abnormal perception/thought. Excluding identified outliers resulted in comparable estimates. Whilst heterogeneity reduced to 0% across domains, this was only interpretable for affective dysregulation, which had two remaining studies after exclusions, and abnormal perception/thought, which had no outlier studies.

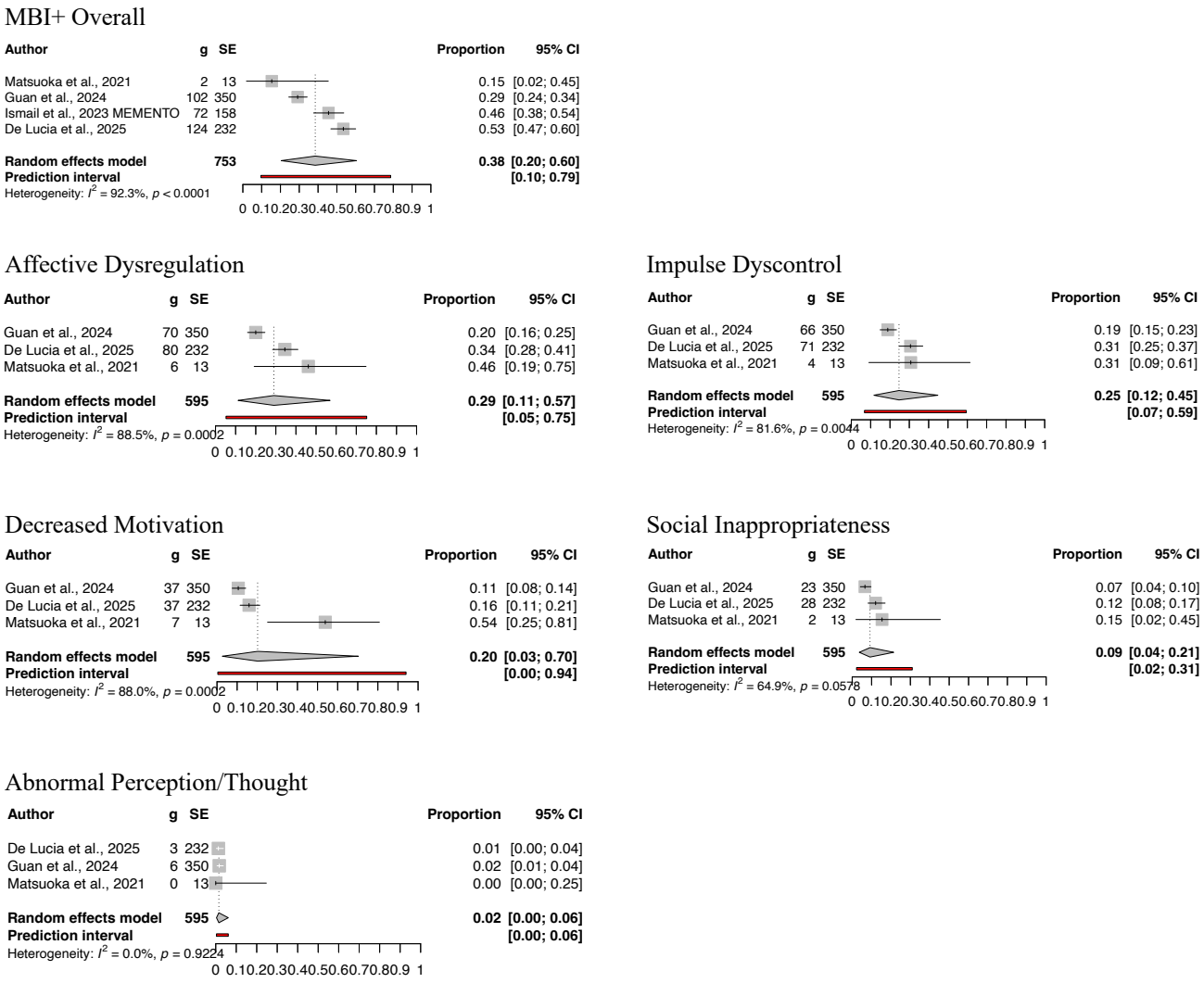



*Figure 4: Forest Plots of MBI Overall and Domain-level Estimated Pooled Prevalence in MCI Individuals (Secondary Meta-Analysis)*

Four additional studies were narratively synthesised for MCI, due to lacking persistence and one study (Park et al., 2025) reporting an overlapping dataset to the meta-analysis above. The latter clinic-based study reported MBI prevalence as 52.70%, with domain-level prevalence of 34.10%-affective dysregulation, 33.90%-impulse dyscontrol, 15.60%-decreased motivation, 9.10%-social inappropriateness, and 1.90%-abnormal perception/thought (Park et al., 2025). Domain-level prevalence demonstrated the same frequency pattern as the pooled analysis, although absolute estimates were higher. The other three studies (Sheikh et al., 2018; Yokoi et al., 2019; Yoon et al., 2023) also reported elevated MBI prevalence in MCI individuals ranging from 49.60-85.30%, and domain-level patterns showed the same ordering as the pooled analysis. Gill and colleagues (2021) reported a 43% prevalence for impulse dyscontrol, which

fell within the overall confidence interval of pooled estimates and was broadly comparable with population-based studies.

Supplementary meta-analyses were completed for population-based studies (Mortby et al., 2018; Vassilaki et al., 2026) and secondary cohort studies which did not meet persistence (Gill et al., 2021; Sheikh et al., 2018; Yokoi et al., 2019; Yoon et al., 2023; Appendix A5), with largely comparable results to the above narrative synthesis, although pooled prevalence was lower in population-based studies. Pooled prevalence estimates were generally higher when including non-persistent studies, and heterogeneity was substantially higher. These findings show that relaxing the persistence criterion results in higher and more variable prevalence estimates, consistent with the inclusion of transient NPS rather than persistent MBI.

*Table 6: Summary of Pooled Prevalence of MBI Domains*

| | Pooled prevalence (95% CI) – Secondary meta-analyses | | | | |
|---|---|---|---|---|---|
| MBI Domains<br>Population | Affective dysregulation | Impulse dyscontrol | Decreased motivation | Social inappropriateness | Abnormal perception/thought |
| CN (*k*=3) | 13.31% (0.71-76.65%) | 12.45% (0.69-74.49%) | 4.66% (0.20-53.81%) | 1.02% (0.32-3.17%) | 0.29% (0.03-2.46%) |
| MCI (k=3) | 29.02% (11.21-56.97%) | 24.67% (11.69-44.77%) | 20.20% (2.64-70.28%) | 9.20% (3.64-21.40%) | 1.51% (0.36-6.12%) |

MBI Risk to Dementia in CN Individuals

Overall Risk

It was not possible to complete a meta-analysis pooling HRs in CN individuals due to overlapping databases in two studies, and one study not meeting persistence (Ruthirakuhan et al., 2022). Whilst between-study differences were evident, the presence of any MBI symptom was consistently associated with increased risk of cognitive decline and dementia. Guan and colleagues (2024) evaluated progression to either MCI or dementia in CN individuals, reporting a HR of 2.73 (95% CI 1.72, 4.31). In a research-based cohort that assessed MBI across a one-month range, Ruthirakuhan and colleagues (2022) reported a HR of 1.75 (95% CI 1.56-1.96) for progression to clinically-diagnosed AD, and HR of 1.59 (95% CI 1.07-2.37) for incident risk of neuropathology-confirmed AD. Ismail and colleagues (2021) reported on odds of dementia development in individuals not meeting SCD criteria (i.e., CN individuals), and reported an adjusted odds ratio (AOR) of 19.23.

Domain-level Risk

At the domain-level, Ruthirakuhan and colleagues (2022) reported HRs in non-persistent MBI for clinically-diagnosed AD, in order of lowest to highest risk, as: affective dysregulation-1.35HR (95% CI 1.18-1.54), decreased motivation-1.77HR (95% CI 1.47-2.14), impulse dyscontrol-2.02HR (95% CI 1.75-2.32), social inappropriateness-2.25HR (95% CI 1.67-3.03), and abnormal perception/thought-6.49HR (95% CI 4.51-9.34).

MBI Risk to Dementia in SCD Individuals

Overall Risk

Ghahremani and colleagues (2025) reported on risk to incident dementia in a subset of SCD within their cognitively healthy population, demonstrating a HR of 1.99 (95% CI 1.46-2.71). When exploring risk in both CN (N=8625) and SCD (N=3485) individuals, a higher HR of 2.76 (95% CI 2.27-3.35) was reported. Ismail and colleagues (2021) reported an AOR of 9.33 to dementia in SCD individuals.

Domain-level Risk

Domain-level risk was only described in the combined CN and SCD group by Ghahremani and colleagues (2025). Incident dementia risk was reported as: affective dysregulation-2.93HR (95% CI 2.31-3.72), impulse dyscontrol-3.08HR (95% CI 2.42-3.93), decreased motivation-6.47HR (95% CI 4.66-8.97), social inappropriateness-7.86HR (95% CI 5.33-11.60), and abnormal perception/thought-15.80HR (8.43-29.63).

MBI Risk to Dementia in MCI Individuals

Overall Risk

A total of three datasets (Guan et al., 2024; Ismail, Leon et al., 2023, Memento and ADNI) were included in the meta-analysis for incident dementia risk in MCI individuals. A forest plot is presented in Figure 5. The estimated pooled HR of 3.28 (95% CI 2.45-4.41) indicated that MBI was associated with an increased risk of incident dementia. No significant heterogeneity was reported ($I^2$=0%, $p$ = .8730). All leave-one-out sensitivity analyses estimates remained statistically significant, indicating that the association between MBI and incident dementia risk was not driven by any single dataset. No outlier studies were identified, with all standardised residuals below ±2. However ongoing caution should be taken when interpreting sensitivity analyses results given the limited number of studies pooled.

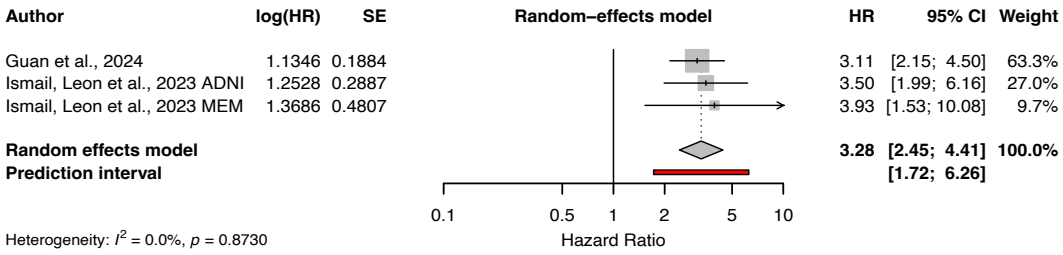



*Figure 5: Forest Plot of MBI Estimated Pooled Hazard Ratios in MCI Individuals*

Two non-persistent MBI studies also reported increased risk of dementia in MCI individuals. A smaller cohort demonstrated an unadjusted HR of 1.13 to dementia progression, although this study did not report confidence intervals (Yokoi et al., 2019). A larger cohort study reported a HR of 1.78 to AD specifically, after adjusting for significant covariates (Yoon et al., 2023) and was included in the supplementary meta-analysis (Appendix A5). An additional study (McGirr et al., 2022) reported on progression from MCI to dementia in individuals with MBI and found an AOR of 2.10. However, this study was excluded from the meta-analysis due to difference in effect type.

Domain-level Risk

Two studies reported on domain-level risk to dementia in MCI individuals albeit did not meet the persistence criterion (Yokoi et al., 2019; Yoon et al., 2023). The incident risk to dementia ranged between 0.75-1.37HR for affective dysregulation, 0.96-1.92HR for impulse dyscontrol, 1.27-2.13HR for decreased motivation, 1.60-1.93HR for social inappropriateness, and 2.26-2.71HR for abnormal perception/thought. The supplementary meta-analysis pooled HRs from both studies, with substantial heterogeneity across domains ($I^2$ ≥70.1%), except for abnormal perception/thought ($I^2$=0%).

Prevalence and Risk in Combined Studies

Whilst data from combined CN, SCD, and/or MCI studies were not synthesised in this review, prevalence estimates and incident dementia risk outcomes were broadly in keeping with results from included studies. The pattern of most-to-least frequent domains was largely consistent with results from individual cognitive groups (Ghahremani et al., 2025; Gosselin et al., 2023; Guan, Chen et al., 2022; Guan, Rockwell et al., 2022; Guan et al., 2023), despite two studies not meeting the persistence criterion. Ebrahim and colleagues (2023) evaluated the affective

dysregulation domain and reported a relatively high prevalence of 26% and an almost two-fold increased risk of dementia (1.76HR). Results from combined cognitive groups also suggested that least prevalent domains had greater risk of incident dementia. In studies combining CN samples with SCD or Cognitive-Impairment-Not-Dementia (CIND), incident risk ranged between 2.76HR (Ghahremani et al., 2025) and 4.35HR (Kan et al., 2022), respectively. In studies combining CN, SCD, and MCI, incident risk ranged from 2.13-3.92HR when at least annual persistence was met (Ghahremani et al., 2023; Guan et al., 2023). In CN and MCI individuals, risk of progression to AD specifically was two-fold (Sharif et al., 2025), and a study evaluating associations between abnormal perception/thought and all-cause dementia reported a four-fold increase in risk (Ismail, Ghahremani et al., 2023).

## Discussion

The present systematic review and meta-analysis findings indicate that MBI is present in non-dementia older adults, and prevalence increases alongside cognitive decline. Notably, a stable pattern of domain-level prevalence was found regardless of cognitive function. The most prevalent domains were consistently reported as affective dysregulation and impulse dyscontrol, followed by decreased motivation, and the least prevalent domains as social inappropriateness followed by abnormal perception and/or thought. Results also demonstrated the association between MBI and incident dementia across groups. Domain-level risk patterns were relatively stable, with the less prevalent domains associated with higher risk. Abnormal perception/thought consistently showed the largest effect sizes of MBI domains, across and within combined cognitive groups. Integrating domain-level prevalence and risk results therefore strengthens evidence supporting MBI as a relatively common prodromal neurobehavioural syndrome associated with an elevated risk of all-cause dementia.

Across included prevalence studies, the relative frequency of MBI domains was highly consistent, regardless of cohort type (population-based vs. clinical-research), geographic region (North America, Australia, Asia), or measurement method (i.e., ISTAART persistence criterion, NPI/NPI-Q vs MBI-C). These factors nevertheless impacted absolute prevalence estimates and contributed to the substantial heterogeneity observed. Persistent MBI studies generally reported lower and more consistent prevalence estimates compared to including possibly transient MBI/NPS. Only one study used the MBI-C (Matsuoka et al., 2021), reporting lower prevalence estimates. The study was limited by a small sample size however results were consistent with evidence, including a SCD study which found MBI prevalence estimates halved with the MBI-C compared to the NPI-Q (Tolentino et al., 2025). Memory clinics reported higher prevalence compared to population-based studies. Despite substantial heterogeneity, the pattern of domain-level prevalence was highly stable, and consistent with the only prior systematic review and meta-analysis (Pan et al., 2021). The current results pooled lower domain-level prevalence rates compared to the prior review in CN individuals, and broadly similar results for MCI. Differences likely reflected the more stringent inclusion criteria in the present review. Quality appraisal results included sampling and representativeness concerns, largely reflecting the lack of population-based estimates, and unclear reporting of response rates and sample coverage. Synthesised prevalence estimates should therefore be interpreted cautiously.

Longitudinal studies included in this review consistently found MBI to be associated with an elevated risk of incident dementia. In CN individuals, Ruthirakuhan and colleagues found almost doubled dementia risk for individuals with MBI compared to those without (2022), although this estimate was limited by the NPI-Q's one-month range. A larger effect size, indicating an almost three-fold elevated risk, was observed when cognitive decline to either MCI or dementia was considered (Guan et al., 2024). This may have reflected the broader outcome criteria and persistent symptoms being measured across annual follow-ups. Associations with elevated risk were observed for both all-cause dementia and AD specifically, including post-mortem diagnoses (Ruthirakuhan et al., 2022). Evidence has further indicated associations between MBI and accelerated cognitive decline prior to dementia onset, supporting MBI as a potential early behavioural marker of underlying neurodegenerative risk (Creese et al., 2019; Rouse et al., 2024). In MCI individuals, the estimated pooled HR of 3.28 for incident dementia in this study was robust, with minimal heterogeneity across three datasets. This aligns with previous evidence demonstrating MBI co-occurring with cognitive impairment confers greater dementia risk than MCI alone (Taragano et al., 2018). Similar increased risk has been observed in individuals with co-occurring MBI and SCD (Ismail et al., 2021). MBI may therefore provide additional prognostic information regarding dementia risk, before measurable cognitive impairment and beyond isolated cognitive status (Guan et al., 2023). In contrast to prevalence estimates, greater confidence in results synthesised by risk studies was supported by the quality appraisal, with rather robust prognostic methodology and low risk of bias across key areas. However, one study (i.e., Yokoi et al., 2019) should be more cautiously interpreted, as MBI was assessed across one-month and domain mapping included items removed from ISTAART, i.e., sleep/appetite (Ismail et al., 2016; Sheikh et al., 2018). Across cognitive groups, studies measuring persistent symptoms reported the strongest associations with dementia risk, providing further evidence that persistent MBI may represent a more robust marker of underlying neurodegenerative risk compared to transient NPS (Guan et al., 2023).

In CN older adults, a six-fold greater risk for AD was reported by Ruthirakuhan and colleagues for individuals experiencing abnormal perception/thought (2022), consistent with a recent, large-scale study applying particularly strict persistence, where risk associated with psychosis-related symptoms was double that of the next highest domain, social inappropriateness, in CN and SCD individuals (Ghahremani et al., 2025). In individuals with MCI, non-persistent studies

reported the highest HRs for psychosis-related MBI symptoms (Yokoi et al., 2019; Yoon et al., 2023) and the supplementary analysis reported strongest pooled effect sizes for abnormal perception/thought (2.33HR) compared to more common domains (1.04-1.70HR). Although the graded risk pattern of domains was not perfectly inverse to the prevalence hierarchy, uncommon domains consistently indicated greater risk. Similarly, risk estimates were higher in CN individuals, which may reflect the greater relative prognostic contribution of late-life emergent MBI when occurring in the absence of established cognitive impairment. In contrast, NPS in MCI are more common and heterogenous in aetiology (Aytulun & Erden-Aki, 2022). This hypothesis is consistent with NPS evidence, where psychosis-related symptoms in older adults without cognitive impairment have been associated with neurodegenerative disease. Liew (2020) reported greater HRs for psychotic symptoms compared to affective NPS (3.6 vs 1.5HR), and these symptoms were more strongly associated with non-AD dementias. Heterogeneity in domain-level risk may reflect true biological variability, as different domains could map onto distinct neurodegenerative pathways and have varying associations with dementia subtypes (Angelopoulou, Papageorgiou & Papatriantafyllou, 2026). Substantial heterogeneity within the evidence-base highlights the need for future research and clinical settings to adopt standardised, up-to-date assessment protocols for MBI, and report sample characteristics across domains to improve comparability.

The present results were broadly consistent with growing neuroscientific research linking MBI with established markers of neurodegeneration, such as amyloid and tau burden, structural atrophy, and neural network dysfunction (Angelopoulou, Papageorgiou & Papatriantafyllou, 2026; Jin et al., 2023). These findings provide biological plausibility for MBI potentially reflecting underlying neurodegenerative processes. Although domain-level evidence remains limited, psychosis-related symptoms have been linked to both all-cause and AD-pathology (Ismail, Ghahremani et al., 2023).

The relatively common presence of MBI suggests that this syndrome should be more carefully considered in those at risk of developing dementia. Key clinical implications include early detection, risk stratification, and targeted pre-dementia interventions (Aytulun & Erden-Aki, 2022). Stable domain-level prevalence and risk patterns suggest that assessing individual domains may provide clinically meaningful information beyond identifying MBI alone. Emergent late-life delusions and hallucinations may warrant closer monitoring or further investigation, particularly in the absence of measurable cognitive impairment, given the robust

associations observed with incident dementia. Whilst more prevalent domains appeared less specific as risk markers, they were nevertheless associated with neurodegenerative disease and should be considered within comprehensive older adult assessments (Aytulun & Erden-Aki, 2022). Use of the MBI-C in clinical and research settings may facilitate early identification of at-risk individuals (Ismail et al., 2017). MBI may represent a clinically accessible prodromal marker of dementia risk, with measurement approaches providing low-cost, scalable additions to risk assessment that could be readily implemented in older adult settings (Angelopoulou, Papageorgiou & Papatriantafyllou, 2026).

This review is strengthened by evaluating both prevalence and dementia risk estimates across MBI and its five domains, enabling comparisons between symptom frequency and prognostic significance in clinically meaningful groups. MBI measurement accuracy within meta-analyses benefited from stringent inclusion criteria and a broader supplementary analysis was also done. Whilst considerable heterogeneity was recognised, the mix of cohorts and designs supported generalisability. Limitations include the substantial heterogeneity between studies arising from methodological, clinical, and population-level differences, and only one study used the MBI-C, limiting comparisons between measurement tools. Results were thus predominantly NPI-based. Most evidence was derived from overlapping databases, and lack of measuring persistent MBI restricted the number of studies included in the meta-analyses. This limited sensitivity analyses and meta-regression was not feasible (Higgins et al., 2024). As study follow-ups tended to be annual, pooled results may have been lower than true prevalence and risk associations when compared to studies that may have utilised a six-month range and the MBI-C, with greater symptom coverage (Ismail et al., 2017).

Future studies should prioritise standardised MBI criteria and measurement approaches to reduce heterogeneity between studies. Further evaluation of individual cognitive groups may support prognostic understanding and strengthen the evidence-base for dementia risk in individuals without cognitive impairment, where early detection and prevention may be most impactful. Domain-level research may also support exploration of emerging subtypes, given the mixed evidence of MBI being associated with AD and other dementia types. In conclusion, this review highlights the importance of recognising newly emergent neuropsychiatric and behavioural symptoms in older adults, given the relatively common prevalence of MBI in non-dementia individuals and evidence that their presence is consistent with an elevated risk of subsequent dementia.

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# Chapter 2

Consideration of Traumatic Brain Injury History within Routine Dementia Assessments in Older Adults

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## Plain Language Summary

**Title:**

Consideration of traumatic brain injury (TBI) history within routine dementia assessments in older adults.

**Background:**

There is growing evidence highlighting TBI as a risk factor for dementia, in that having a lifetime history of TBI increases chances of developing dementia. A TBI is when injury to the brain is caused by an outside force, and dementia refers to conditions that affect thinking, memory, and everyday activities. There is however limited information on how TBI history should be considered within dementia assessments. In older adults, TBI and/or dementia are common, therefore this population may benefit from improved TBI identification.

**Aims:**

This study aimed to explore whether a standardised questionnaire could help identify and assess TBI history during dementia assessments, after adapting the tool for use within Older Adult-Community Mental Health Teams (OA-CMHTs).

**Research Questions (RQ):**

The primary RQs explored whether use of the adapted TBI questionnaire increased the number of dementia assessments where TBI history was considered and recorded as present or absent, and whether it increased identification of positive TBI history during dementia assessments in OA-CMHTS.

The secondary RQ explored clinicians' experiences of using the questionnaire and their views on its usefulness, ease of use, and potential impact compared to their usual practice.

**Methods:**

12 clinicians who routinely complete dementia assessments took part in the study, recruited from multiple OA-CMHTs. Two services in Glasgow, Scotland, were selected. Clinicians and services were recruited through older adult Psychology departmental meetings and emails. One service used the adapted TBI questionnaire for two-months, whilst the other had no change to

their usual processes. This allowed the assessment and identification of TBI history to be compared between the two services.

The study used both quantitative and qualitative methods. To explore the primary RQs, information from dementia assessments was analysed using statistical tests. Clinicians therefore used and documented information from the questionnaire during their assessments. To explore the secondary RQ, clinicians who used the questionnaire took part in a semi-structured interview with the researcher about their experiences and views of using the tool during older adult dementia assessments. The interviews were analysed to identify common themes in the data.

**Main Findings and Conclusions:**

The results showed that use of the standardised TBI questionnaire significantly increased the number of assessments where lifetime TBI history was considered and documented as either present or absent. It also increased the identification of individuals with a previous TBI. Participants described consideration of TBI as useful and manageable within their routine older adult dementia assessments. They felt that the questionnaire was better than their usual approach and reduced the risk of missing TBI information. Participants also described subtle ways in which considering TBI could help them better understand the difficulties and personal history of older adults undergoing dementia assessments, and could support more personalised care. Overall, the findings suggest that TBI history should be considered during dementia assessments and that a standardised questionnaire provides a practical approach that could be used in OA-CMHT services.

## Abstract

**Background**: Although traumatic brain injury (TBI) is a recognised risk factor for dementia, there is limited guidance on how lifetime TBI history should be considered in routine dementia assessments with older adults. This study examined whether an adapted Ohio State University Traumatic Brain Injury Identification Method (OSU TBI-ID) could support consideration of TBI during older adult dementia assessments. The study also explored clinicians' experiences of the tool, including its usefulness, feasibility, and perceived impact compared to routine practice.

**Methods**: A mixed-methods design was used. Quantitative analyses examined whether the adapted OSU TBI-ID increased rates of TBI documentation and assessment (as either present or absent), and identification of positive TBI history. Qualitative semi-structured interviews with clinicians who used the adapted tool were analysed using reflexive thematic analysis.

**Results**: Compared with a control service, the intervention service utilising the adapted OSU TBI-ID demonstrated significant increases in rates of TBI documentation, assessment, and identification of positive TBI history. Four themes and eight subthemes were generated from participant interviews. Qualitative findings indicated that clinicians viewed the adapted tool as compatible with existing assessments, perceived it as more useful than routine practice, and described subtle yet meaningful contributions to understanding clinical presentations and informing personalised dementia care.

**Conclusions**: These findings support routine consideration of lifetime TBI history in older adult dementia assessments and suggest the OSU TBI-ID as a feasible and useful clinical approach to systematic assessment and documentation of lifetime TBI history within older adult services.

## Introduction

Globally, there are estimated to be over 50 million people living with dementia (World Health Organisation, 2020), with greater prevalence expected as young mortality declines (Livingston et al., 2020). In the United Kingdom (UK), an estimated 7% of people aged over 65 years have a diagnosis of dementia, and rates markedly rise with increased age (National Institute for Health and Care Excellence (NICE), 2018). In recent years, traumatic brain injury (TBI) has increasingly been recognised as a dementia risk factor and was listed as a potentially modifiable risk factor in the 2020 Lancet Commission on 'dementia prevention, intervention, and care'. This includes TBIs ranging from mild-to-severe, although risk was noted to increase with injury severity and frequency (Livingston et al., 2020).

The relationship between TBI and dementia has been a particular focus of research on veterans and professional athletes (LoBue et al., 2019), which highlighted increased rates of cognitive impairment and odds of developing dementia in individuals with a lifetime history of TBI (Mendez, 2017). The evidence-base has more recently broadened, as both dementia and TBI have been recognised as significant public health concerns (Livingston et al., 2020), with review findings indicating a significant association between TBI history and increased neurodegenerative risk (Gu, Ou & Liu, 2022; Zhang et al., 2021). Risk of dementia following moderate-to-severe or repeated injuries is robust and established (Livingston et al., 2020). Though research on mild TBI severity is more nuanced, increased risk of dementia development has nevertheless been recognised (Gu, Ou & Liu, 2022; Snowden et al., 2020).

Whilst all-cause dementia is associated with lifetime TBI history, underlying neurodegenerative mechanisms remain poorly understood (Al-Rubaie, 2025; LoBue et al., 2019). Some studies have found Alzheimer's Disease (AD) to be associated with moderate-to-severe TBI compared to individuals without such history (Zhang et al., 2021), whilst other studies have not found an association with AD specifically, despite reporting almost doubled odds for developing dementia more broadly (Gu, Ou & Liu, 2022). Increased likelihood of developing other common dementia types have also been reported, including Fronto-temporal Dementia and Parkinson's disease dementia (LoBue et al., 2019; Mielke et al., 2022). Chronic Traumatic Encephalopathy, a syndrome associated with repeated head injuries, has additionally been suggested as a potentially distinct neuropathological pathway to neurodegenerative disease post-TBIs (LoBue et al., 2019; Mendez, 2017).

Distinct cognitive, behavioural, and/or neuropsychiatric presentations have been suggested in individuals with dementia and TBI history. For example, differences in cognitive performance on testing have been reported (Dams-O'Connor et al., 2013), although findings are inconsistent across studies (Sayed et al., 2013). Greater neuropsychiatric symptom burden has been found, including higher rates of depression, apathy, and irritability in dementia individuals with TBI history compared to those without such history (Bray et al., 2021; Dams-O'Connor et al., 2013; Sayed et al., 2013). These findings suggest that consideration of TBI history may contribute to understanding individual differences in dementia presentation. Additionally, worse outcomes following TBI in later-life have been described, which may reflect age-related factors including reduced cognitive reserve and greater medical comorbidity (Depreitere et al., 2025). Identifying comprehensive lifetime TBI history may therefore be particularly important during dementia assessments with older adults.

Despite growing, robust evidence of increased dementia risk associated with TBI, guidance on how TBI history should be considered and identified within dementia assessments remains limited. Recommendations for dementia assessments indicate that TBI should be explored alongside other neurological conditions during clinical interview (Galasko, 2013), however guidance is limited, and some studies suggest TBI is insufficiently considered within diagnostic assessments (Sherry et al., 2025; Shively et al., 2012). This may be particularly relevant with older adults, given the increased prevalence of both dementia and TBI in this age-group (Depreitere et al., 2025; Gardner et al., 2020). The highest incidence rates of TBI are reported in older adults (Gardner et al., 2020) and TBIs in this population are thought to be under-recognised as older adults, despite greater risk of poor outcomes (Sherry et al., 2025). The need to consider TBI in older adult dementia care is evidently warranted. Additionally, this aligns with national and international guidelines emphasising the benefit of comprehensive understanding of individual history to deliver person-centred, post-diagnostic care (e.g., Fazio et al., 2018; NICE, 2018; Scottish Intercollegiate Guidelines Network (SIGN), 2023). TBI-related information obtained at assessment may therefore be relevant for formulation development, optimising intervention strategies, and reducing the risk of negative outcomes for people living with dementia (Dams-O'Connor et al., 2014; Livingston et al., 2020). Furthermore, details of circumstances surrounding a significant brain injury event may support trauma-informed approaches and improve understanding of presentations and distress as dementia progresses. For example, the risk of re-traumatisation has been noted as dementia

progresses, and significant life events may provide additional context when an individual with dementia experiences altered reality and regression in their timeline, and may re-experience a traumatic event (Mackenzie et al., 2015). Robust consideration of lifetime TBI history may aid differential diagnoses, highlight potential cognitive or behavioural difficulties requiring further assessment and/or consideration during treatment planning, or provide a greater understanding of personal history for future care.

A standardised, validated measure, considered gold-standard for assessing lifetime history of TBI is the Ohio State University Traumatic Brain Injury Identification Method (OSU TBI-ID; Corrigan & Bogner, 2007a). Consistent evidence has supported improved identification of TBI history when using this measure, compared to informal or brief screens, and use of the tool has been validated in older adult populations (Gardner et al., 2020; Schneider-Cline, Bush & McKelvey, 2019), including those with mild cognitive impairment (MCI) (Gardner et al., 2020). Evidence for use in dementia assessments is limited, however. The OSU TBI-ID's self-report methodology is common practice in TBI research and a validated method for identifying head injury history (Corrigan & Bogner, 2007a; 2007b). Self-report helps overcome issues such as records underestimating prevalence for injuries that did not require or result in hospital attendance, and for older adults specifically, such data may not exist or be readily accessible (Gardner et al., 2020). As memory is expected to generalise with age (Grilli & Sheldon, 2022), specific queries used within structured tools may help obtain more detailed information compared to informal, general questions. Unlike brief screens, the tool systematically captures injury characteristics including severity, frequency, and timing across the lifespan (Corrigan & Bogner, 2007b); factors recognised as contributing to dementia risk (Livingston et al., 2020).

In summary, there is limited information on how TBI history should be considered within dementia assessments. Given the established risk of dementia in individuals with lifetime TBI history and the high prevalence of both conditions in older adults (Livingston et al., 2020), improved consideration of TBI may be warranted for individuals undergoing memory assessments. However, to date, little is known about whether structured TBI assessments are feasible or useful within routine dementia assessment pathways.

## Aims

Quantitative:

This study aims to explore how TBI may be considered within routine dementia assessments within UK National Health Service (NHS) Older Adult Community Mental Health Teams (OA-CMHTs). The primary research question, investigated through quantitative analysis, was divided into a main (1a) and exploratory question (1b):

- 1a: Does use of an adapted OSU TBI-ID increase the proportion of assessments in which history of TBI is documented and assessed as either present or absent?
- 1b: Does use of an adapted OSU TBI-ID lead to an increased number of assessments with TBI history being identified as present?

Qualitative:

A secondary research question, investigated through qualitative analysis, aimed to explore the experiences of clinicians using the adapted OSU TBI-ID in their routine dementia assessments, and their perceptions on the tool when compared to routine practice.

- 2: How useful, feasible, and impactful did clinicians find the adapted OSU TBI-ID questionnaire within their routine dementia assessments with older adults?

# Methods

## Ethics and NHS Management Approval

A study protocol was developed (Appendix B2) and granted ethical approval (Yorkshire & The Humber – Bradford Leeds Research Ethics Committee Reference: 25/YH/0113; Appendix B3). NHS Greater Glasgow and Clyde (GG&C) Research & Innovation approval was granted (UGN25NE094; Appendix B4). Patient data was accessed through the local health record system without patient consent with Caldicott Guardianship Approval (Appendix B5).

## Participants

12 clinicians participated in the qualitative arm of this study, recruited from OA-CMHTs within NHS GG&C. Six participants were Community Psychiatric Nurses (CPN), including one Nurse Team Lead, four were Clinical Psychologists (CP), and two were Health Care Support Workers (HCSW). No additional demographic characteristics were collected for participants.

## Measures

An adapted version of the OSU TBI-ID was used in this study (Appendix B6). The OSU TBI-ID is a structured interview tool that comprehensively identifies and explores lifetime TBI history. This standardised measure has robust evidence supporting its reliability and validity (Bogner & Corrigan, 2009; Corrigan & Bogner, 2007a), including validity in older adults and MCI (Gardner et al., 2020). Although the tool can be used freely, permission from the test author, Professor Corrigan, was obtained to make minor adaptations, based on considerations for older adults undergoing dementia assessments. Minor adaptations included adjustments to wording (e.g., "accident and emergency" to replace "emergency room", response options (i.e., adding "don't know" to yes/no items), contextual examples, and administration instructions (i.e., option to document corroboration by significant others and/or medical records) to improve suitability for older adults and the UK/Scottish context. The specific changes made are outlined in Appendix B7.

## Study Design and Procedures

This study utilised a mixed-methods design.

### Quantitative Study Design and Procedures

Clinicians routinely involved in completing dementia assessments in OA-CMHTs were recruited from two NHS GG&C services in Scotland. Service 1 acted as the 'intervention' site and implemented the adapted OSU TBI-ID in dementia assessments, whilst Service 2 acted as the 'control' site. Clinicians in the control service were not involved in the study, although patient data from assessments completed by Service 2 were obtained.

Patient data was collected for both services at two timepoints, to evaluate the primary research questions. Time 1 (i.e., pre-intervention) involved all memory-based assessments completed in Service 1 and Service 2 between October and November 2024. Time 2 (i.e., post-intervention implementation) involved all memory-based assessments in both services between October and November 2025. This allowed a comparison to be made between Service 1, which considered TBI with a standardised tool, and Service 2, which had no change to their assessment process.

Clinical documentation from dementia assessment referrals at Time 1 and 2 were reviewed to determine whether TBI was assessed and documented as either present or absent, and whether TBI history was identified as present. Patients with a known dementia diagnosis were excluded. Neuropsychological assessments were excluded as these do not reflect the 'initial' memory assessment of the OA-CMHT dementia pathway.

Quantitative analyses were initially conducted with assessments completed by HCSWs, CPNs, and Occupational Therapists (OTs), as this reflects results at the initial assessment stage of the dementia pathway. A secondary, supplementary analysis was conducted with Psychiatry assessments included, as these consultations reflect the next stage of assessment within Service 1 and 2, and instances where the psychiatrists were the first point of clinical contact.

A target sample size of 160 assessments across both services and timepoints was determined by reviewing a recent audit from a GG&C OA-CMHT. This target met criteria for the planned statistical analysis, and using G*Power calculations (Buchner et al., 2020), the minimum effect size that could be detected was calculated to be Phi = 0.22 (Small effect).

*Table 1: Study Design*

| **Service x Time** | **Time 1 (Pre-intervention)** | **Time 2 (Post-intervention)** | **Research Hypothesis** |
|---|---|---|---|
| Service 1 (Intervention) | October-November 2024<br><br>Memory clinics, without TBI tool<br><br>Disciplines involved: HCSWs, CPNs, OTs, Psychiatrists | October-November 2025<br><br>Memory clinics, with recruited participants using TBI tool<br><br>Disciplines involved: HCSWs (using TBI tool) and CPNs, OTs, and Psychiatrists (not using TBI tool) | Increased number of assessments which assess TBI<br><br>Increased identification of positive TBI history |
| Service 2 (Control) | October-November 2024<br><br>Memory clinics, without TBI questionnaire<br><br>Disciplines involved: CPNs and Psychiatrists | October-November 2025<br><br>Memory clinics, without TBI questionnaire<br><br>Disciplines involved: CPNs and Psychiatrists | No significant change in the number of assessments which assess TBI<br><br>No significant change in identification of positive TBI history |
| TBI: Traumatic Brain Injury, HCSWs: Health Care Support Workers; CPNs: Community Psychiatric Nurses; OTs: Occupational Therapists | | | |

Qualitative Study Design and Procedures

The study recruited participants who had clinical experience using the adapted TBI tool to explore the qualitative, secondary research question via a semi-structured interview with the researcher. Participants were recruited from a range of OA-CMHTs, including the two HCSWs in Service 1. All participants were recruited with the same inclusion criteria: clinicians working in OA-CMHTs, routinely involved in dementia assessments. No additional exclusion criteria were applied. A target sample size of 12 was selected to ensure sufficient participants for thematic analysis (Fugard & Potts, 2014) and a varied representation of disciplines involved in dementia assessments. Sample adequacy was also considered in relation to information power, reflecting the focused research question, specific participant group with direct experience of using the adapted OSU TBI-ID, and the semi-structured interviews exploring their experiences of its use.

All participants reviewed a participant information sheet (Appendix B8) and received brief training on how to administer the adapted OSU TBI-ID before providing informed consent (Appendix B9). Participants assessed TBI within their routine dementia assessments across two

months before completing the semi-structured interview. Participants were required to use the tool at least once before engaging in the interview. A semi-structured interview protocol was devised (Appendix B10) to aid comprehensiveness whilst allowing flexibility in spontaneously reported experiences to be discussed. This was generated from literature reviews and liaising with OA-CMHT clinicians experienced in undertaking dementia assessments during the study development stage, including a psychiatrist, CPN, and OTs from a service that was otherwise not involved in the study, to minimise potential bias among subsequently recruited participants. Clinicians reviewed the draft interview protocol for appropriateness and provided feedback on whether additional areas required inclusion. Interviews were in-person, lasting 30-50 minutes. Audio recordings were transcribed by the researcher, with personally identifiable information redacted. Pseudonyms are used to maintain confidentiality.

**Data Analysis**

Quantitative Analysis

Chi-square tests of independence were utilised to analyse the primary research questions. Due to sparse (including zero) cell frequencies, the planned combined analyses examining the relatedness between Service and Time was not appropriate. Separate analyses were therefore conducted for the intervention and control services. Fisher's tests were used where expected cell frequencies were below recommended assumptions, to provide a more accurate estimate of statistical significance (Pallant, 2016). The outcome variables were Documentation status (whether TBI history was documented as either present/absent), Assessment status (whether TBI was assessed as either present/absent), and Positive TBI History (whether TBI history was identified as present). Documentation included prior details noted in the current assessment, such as in the referral or past medical history, or newly obtained information in assessment. Clinical notes were required to report either a lack of lifetime TBI or a single, at least Possible TBI, according to the Mayo classification criteria (Malec et al., 2007). Assessment included informal (i.e., an assumed single-question approach, regardless of lifetime history being covered) or formal measures (i.e., any screening tool, including the adapted OSU TBI-ID). Present TBI history required reports of at least Possible TBI (Malec et al., 2007) within Documentation/Assessment status. Statistical analyses were undertaken using IBM SPSS (Version 29.0).

Qualitative Analysis

Information gathered from participant interviews was analysed using a thematic analysis approach (Braun & Clarke, 2022) to systematically and comprehensively explore themes relevant to the use and feasibility of considering TBI within dementia assessments. Braun and Clarke's reflexive thematic analysis six-stage model was used: 1) Familiarisation, 2) Coding, 3) Generating initial themes, 4) Reviewing themes, 5) Defining and naming themes, and 6) Writing up of results (Braun & Clarke, 2006; 2022). Briefly, interview data was repeatedly reviewed and coded. Codes were then grouped into themes to reflect shared patterns of ideas. Open coding was utilised to generate themes that went beyond the interview topic guide and the researcher was cautious to ensure this did not restrict generation of themes to a pre-determined framework of interest. The researcher was an active participant in the generation and organisation of codes and themes, having an interpretive stance and at times seeking out latent themes rather than purely semantic themes, in line with a reflexive thematic analysis approach (Braun & Clarke, 2022). Two members of the research team reviewed themes, with reference to codes, generated by the primary researcher.

## Results

### Quantitative Results

Dataset Characteristics

In Service 1 (intervention), 75 datasets were reviewed (Time 1 $n$ = 38; Time 2 $n$ = 37). Assessments were completed by HCSWs, CPNs and OTs. In Service 2 (control), 82 datasets were reviewed (Time 1 $n$ = 57, Time 2 $n$ = 25). For the supplementary analysis with psychiatrists, 174 datasets were reviewed in Service 1 and 270 in Service 2. A total 443 datasets were therefore included in the analysis.

Not all clinicians in Service 1 were successfully recruited, and data obtained during Time 2 therefore included assessments with and without use of the adapted OSU TBI-ID.

Research Question 1a: Does use of an adapted OSU TBI-ID increase the proportion of assessments in which history of TBI is documented and assessed as either present or absent?

Table 2 provides a summary of quantitative results. At Time 1 (pre-intervention), none of the 38 assessments (0%) in Service 1 documented TBI history. At Time 2 (post-intervention), when participants in Service 1 utilised the adapted OSU TBI-ID, 23 assessments (62.2%) documented the presence or absence of TBI history, whilst 14 assessments (37.8%) did not. A chi-square test for independence (with Yates' Continuity Correction) indicated a significant association between Time and Documentation status, $\chi^2(1, N = 75) = 31.21, p < .001, phi = .67$. The phi coefficient value of .67 indicates a large effect size according to Cohen's (1988) criteria.

In Service 1, identical results were found for Assessment status as described above for Documentation status. At Time 1, none of the assessments indicated consideration of TBI (0%). At Time 2, the same 23 assessments (62.2%) assessed TBI history to be either present or absent, indicating considerable increase in TBI consideration after introducing the adapted tool. A chi-square test for independence (with Yates' Continuity Correction) indicated a significant association between Time and Assessment status, $\chi^2(1, N = 75) = 31.21, p < .001, phi = .67$.

Results differed for Service 2. At Time 1, six assessments (10.5%) documented presence or absence of TBI history from existing information, and 51 assessments (89.5%) did not. At Time 2, two assessments (8.0%) documented TBI history, and 23 assessments (92.0%) did not

document consideration of TBI. A Fisher's Exact Test was carried out due to small expected cell counts and no significant association was found between Time and Documentation status, $p = 1.00$, $phi = .04$.

It was not possible to explore the relationship between Time and Assessment status in Service 2 due to 100% of assessments at Time 1 ($n = 57$) and Time 2 ($n = 25$) not assessing TBI history.

Research Question 1b: Does use of an adapted OSU TBI-ID lead to an increased number of assessments with TBI history being identified as present?

In Service 1, positive TBI history was not identified prior to introduction of the adapted OSU TBI-ID in all 38 assessments (i.e., Time 1 = 0%). At Time 2, TBI history was positively identified in eight assessments (21.6%), whilst the remaining 29 assessments (78.4%) reported absent or unknown history. A Fisher's Exact Test indicated a significant association between Time and Positive TBI history being identified, $p = .002$, $phi = .35$. The phi coefficient value indicated a medium effect size. All positive TBIs identified were through use of the adapted OSU TBI-ID.

In Service 2, six assessments (10.5%) reported positive lifetime TBI history at Time 1, noted from previously existing information such as the referral, compared to 51 assessments (89.5%) identifying either absent or unknown TBI history. At Time 2, one assessment (4.0%) identified a positive TBI history, and the remaining 24 assessments (96.0%) were either absent or unknown histories. A Fisher's Exact Test found no significant association between Time and Positive TBI history, $p = .43$, $phi = .11$.

*Table 2: Summary of Quantitative Results*

| RQ and Outcome Variable | Service | Time 1 n (%) | Time 2 n (%) | Stats. Test | Test Stats. Result | *p* value | Effect size |
|---|---|---|---|---|---|---|---|
| RQ1a: Documented | 1 | 0 (0%) documented | 23 (62.2%) documented | $\chi^2$ | $\chi^2(1, N = 75) = 31.21$ | <.001 | .67 (large) |
| | 2 | 6 (10.5%) documented | 2 (8.0%) documented | Fisher's Exact | - | 1.000 | .04 (small) |
| RQ1a: Assessed | 1 | 0 (0%) assessed | 23 (62.2%) assessed | $\chi^2$ | $\chi^2(1, N = 75) = 31.21$ | <.001 | .67 (large) |
| | 2 | 0 (0%) assessed | 0 (0%) assessed | - | - | - | - |
| RQ1b: Presence of TBI history | 1 | 0 (0%) positive TBI identified | 8 (21.6%) positive TBI identified | Fisher's Exact | - | .002 | .35 (medium) |
| | 2 | 6 (10.5%) positive TBI identified | 1 (4.0%) positive TBI identified | Fisher's Exact | - | .430 | .11 (small) |
| RQ: Research Question; n: number; %: percentage; $\chi^2$: chi-square test of independence; TBI: traumatic brain injury | | | | | | | |

Secondary, Supplementary Analysis:

When including psychiatrists in the analysis, results for all three outcome variables remained the same, indicating that findings were consistent regardless of which discipline completed the dementia assessment (Appendix B11).

**Qualitative Results**

Data generated from participant interviews resulted in four themes. Subthemes were generated to reflect data that fell within main themes without losing nuance and reflecting distinct areas of significance. Supporting participant quotations are provided however for brevity, further quotations are evidenced in Appendix B12.

*Table 3: Overview of Themes and Subthemes*

| Theme | Subtheme |
|---|---|
| A: Compatible with existing assessment | A1: Perceived burden exceeds actual burden<br>A2: Limitations and challenges are not unique to TBI |
| B: Benefits beyond existing assessments | B1: Reduces risk of missed information<br>B2: Utility over routine, informal methods<br>B3: May influence future practice |
| C: Subtle yet meaningful influence in clinical understanding | C1: Linking injury characteristics to presentation |
| D: Subtle yet meaningful context for care | D1: Could inform immediate and future care plans<br>D2: Personalised care by embedding personal history |

Theme A: Compatible with existing assessment

Participants consistently found the adapted OSU TBI-ID to be compatible with their routine dementia assessments. Consideration of TBI was described as integrating easily with existing processes, with minimal practical burden. Limitations described were considered inherent to complexities of dementia assessments with older adults.

Subtheme A1: Perceived burden exceeds actual burden

Participants consistently described the tool as easy and quick enough to integrate into existing assessments. Some clinicians reflected on initial assumptions of greater burden given already comprehensive and time-pressured assessments however found the actual burden minimal. The tool was described as brief, straightforward, and despite a minor learning curve, increased ease with familiarity was noted. Language was appropriate for purpose, population, and setting, and participants did not experience negative responses from patients or informants. Some participants thought the tool supported engagement and rapport, without distracting from the overall assessment. Participants that referenced initial perceived barriers positioned this as due to service pressures and broader systemic factors rather than inherent to TBI consideration.

> *James: "…inclusion of this, as a routine part of care, it would make sense…it doesn't take a long time…at the greatest extent you're talking a five-minute process, but having that extra bit of information would be really helpful…it didn't really detract from your assessment…just logical and easy enough…"*

*Alice: "It didn't add on any time constraints at all to the memory assessment, it just slotted in fine…didn't feel outwith…fitted in quite well…"*

Subtheme A2: Limitations and challenges are not unique to TBI

Participants described potential limitations when assessing TBI history, however consistently framed these as arising from the broader context of dementia assessments and not specific to TBI or the tool. Possible factors raised included engagement variables (e.g., fatigue, anxiety) and the impact of memory/cognitive impairment on self-report reliability. Some injury details were thought to be variable or inaccessible, such as mild TBI being less frequently reported compared to moderate-to-severe injuries, and details such as loss of consciousness potentially being unknown. Nevertheless, no significant modifications to the tool were advised. Participants reported that implementation of the tool within early stages of dementia minimised challenges, as patients are often good historians at initial assessment and inclusion of informant reports helped to corroborate data obtained.

*Helen: "…most of the time the family member would be able to remember but they wouldn't be able to tell you about childhood…if the patient's dementia has progressed enough that they can't remember that or have forgotten it in general, and there's nobody there to corroborate it…that's the only limitation, but that's more the patient rather than the questionnaire"*

Whilst participants denied experiencing challenges or risk concerns when assessing TBI, some identified the potential for trauma disclosure alongside head injury history. Clinicians reported this as core to their routine assessment and clinical skills however, regardless of TBI. Some highlighted training and professional development opportunities as being protective in this context, particularly as prior experience and interests may vary across disciplines or clinicians. Overall, risk (e.g., of distress) was characterised as minimal and manageable.

*Matthew: "…I suppose with anything like this, if there is any trauma, you could unwittingly open the wound…that's a risk with anything that we do with mental health…I don't think I would be doing my job if I*

*wasn't delving into someone's past…I don't think it would be any more risky than anything we normally complete…"*

Theme B: Perceived benefits beyond existing assessment

The adapted OSU TBI-ID was described as adding value beyond routine assessments. The tool was consistently thought to reduce the risk of TBI and relevant characteristics being missed by supporting more complete and accurate assessment of lifetime TBI. The tool was described as addressing a gap in existing, informal approaches, and improving standardisation of TBI assessment. Given the perceived benefits, participants described being more likely to consider TBI in their future assessments.

Subtheme B1: Reduces risk of missed information

Linked to subtheme A2, participants perceived benefits as outweighing any potential limitations. The adapted OSU TBI-ID was described as enhancing accuracy and completeness of TBI history-taking. Structured and specific questions prompted patient recall and supported disclosure of injuries that constitute a TBI, which may have otherwise been overlooked. The tool strengthened clinicians' confidence in capturing accurate, relevant information, including factors that may be particularly relevant for older adults. Participants benefitted from reduced reliance on their own memory, minimising potential clinician bias, and supporting the standardisation of TBI assessment within and across services.

*James: "…people don't think of concussion as a brain injury…even as a fairly experienced clinician in old age, you're not that experienced in TBIs, so having something that standardises it, that takes a lot of that ambiguity out…having that in place really does help guiding things…trying to cut through some of the colloquialisms…someone might be thinking oh well I did have a fall and bang it, but might not think about other situations where head injuries might occur…"*

*Alice: "…I would have probably asked…something like a head injury or knocked your head lost consciousness, but they might not have said yes without being prompted by the detail of the questionnaire…sometimes people don't consider that what has happened has been a head injury…"*

Subtheme B2: Utility over routine, informal methods

Participants reported that they did not previously consider TBI history or relied on informal methods such as a single, broad question, with possible prompts if positive TBI was identified. No participants reported prior use of a standardised assessment measure and participants consistently reported the adapted tool to add value beyond current methods. Informal methods were described as prone to missed or incomplete information and tended to omit lifetime history (e.g., queried TBI following a fall or due to occupational history). Limited access to lifetime medical records in older adults was noted, further supporting utility of the tool.

> *Michelle: "…it would have definitely been missed"*

> *James: "…I would ask about head injuries, but it would normally be a single question, maybe a couple of probes, but with this, it has that bit more detail about things that perhaps I wouldn't have asked…definitely wouldn't have got into that level of detail…I wouldn't have collected some of that information…"*

Some participants reported prior assumptions that TBI would be spontaneously self-reported or well-documented, which they reflected as an inaccurate assumption. Several participants reported that injuries identified during this study would have been missed using previous approaches and were omitted from accessible records.

> *Sandra: "…there would have been so many people that wouldn't even have thought of telling me that and we don't routinely ask…"*

> *Catherine: "…I don't usually ask…if it's not noted down in the [referral]…then I don't ask…if it did happen a while ago…we just can't access [records]"*

Subtheme B3: May influence future practice

Many participants perceived the described added value as encouraging future consideration of TBI in their routine assessments. Preferences for future use was mixed; some favoured standardised administration to ensure injury history would not be missed, whilst others preferred to utilise the tool when TBI was identified or documented in existing information. The overall pattern across interviews suggested an increased awareness of TBI within dementia, and increased likelihood of TBI consideration within future assessments.

Participants who described never previously considering TBI noted an intention to incorporate it into their routine practice, either formally or informally.

> *Callum: "I think it should be like a standard…"*

> *Helen: "I wouldn't mind to keep using it…I'm probably more likely to ask that question in the assessment now…whereas before it would just be after a fall…now it would be more likely…in your life has there ever been any trauma to your head…you don't know what you don't ask…"*

Theme C: Subtle yet meaningful influence on clinical understanding

Some participants were clear in their view of TBI meaningfully influencing their understanding of patient presentations within dementia assessments. Other clinicians initially reported a limited impact however their perspectives evolved with reflections, and these participants subsequently reported that systematic consideration of TBI may meaningfully inform formulation development. The potential impact on understanding patient presentation varied, which supported suggestions made by some participants on the potential value of training clinicians regarding how to consider TBI in dementia.

Subtheme C1: Linking injury characteristics to presentation

TBI was recognised as meaningful for understanding cognitive profiles, and participants described considering it similarly to other established risk factors such as excessive alcohol use. Lifetime history was thought to potentially influence cognitive outcomes and to a lesser extent, behavioural presentations. As interviews progressed, participants who initially reflected being unsure of the potential impact of TBI on clinical understanding reported thinking through specific factors and this evolving their perspectives. Reflections included how TBI may inform differential hypotheses and formulations and therefore support understanding of individual presentations. Timelines of injuries relative to observed cognitive or behavioural changes, distinguishing static and progressive impairments, considering brain vulnerability and premorbid function, and weighing severity and frequency of TBIs were noted as potentially relevant in neuropsychological formulations. Taken together, discussions suggested that systematic consideration of TBI history may meaningfully influence clinical understanding of patient presentations.

*Amy: "…want to be aware of that…what impact it's had…what the impairments are on their neuropsych profile and whether that correlates with the effect they could have had from the TBI and their scans, whether it's a static impairment or not…when the TBI took place, the frequency, how long the person was concussed for, all of these things we know have an impact…would influence the formulation…if the person has recently had a TBI…might not conceptualise that as cognitive impairment as a result of neurodegeneration…could make a difference to your final conclusions…their diagnosis, our understanding…think it makes a big difference…"*

*James: "…it could be that's contributing to your dementia or could be causing it…it's certainty helpful…helping clarify diagnosis potentially…older people with accumulated head injuries over time…are they suffering the aftereffects of an undiagnosed head injury…wouldn't want to accidentally diagnose someone with dementia…features of TBI that might be distinct from your dementia…"*

Theme D: Subtle yet meaningful context for care

Linking with theme C, many participants initially perceived limited impact of TBI consideration translating to clinical consequences and care. However, as participants reflected on this topic and they generated potential implications, their views shifted. Reflections highlighted subtle but potentially meaningful ways that formal assessment of TBI may inform decision-making post-assessment, and personalised formulations and future care planning.

Subtheme D1: Could inform immediate and future care plans

There were tentative reflections of identified TBI within dementia assessments subsequently impacting clinical decision-making and care. Some participants reflected on occasions where identified TBI may alter conclusions of an assessment or suggest additional investigations (e.g., brain imaging, referral to clinical psychology/neuropsychology). This indicated that depending on context, injury history may add to the perceived complexity of a dementia assessment and its outcomes, encouraging further information gathering and targeted support.

*Amy: "…if you're having a feedback appointment…they've had a TBI…say in the last six months, some of the deficits could be attributable to that…you'd want*

*to give information about TBI and how it can impact on cognition, how cognition can change in the future…strategies that could support…future planning…"*

*Vanessa: "…further scans…further investigations…it would open that door to assess further what is actually the cause…not all people with dementia are presenting the same…signpost to different resources…support a family in a different way maybe than if it's just purely a dementia…important to give family the understanding…document everything…more information we have about someone, the more we can support them…*

Participants also described the relevance of TBI history in long-term formulation and intervention, such as informing stress and distress approaches. Participants emphasised the value of TBI being assessed and documented prior to further disease progression. For example, decision-making around medication may be impacted through awareness of prior TBI, and proactive approaches to reduce triggering distress may be supported. Uncertainty was otherwise described in terms of how TBI should be considered in post-diagnostic care.

*Matthew: "I definitely think it would be helpful for things like formulation etcetera…when you're doing a Newcastle model it would be really beneficial, any extra information can be key and actually it would be very good to know because if you've had a brain injury you've almost certainty had a traumatic event that led to the brain injury…"*

Subtheme D2: Personalised care by embedding personal history

Participants consistently described the value of structured TBI assessment in supporting personalised care beyond the initial assessment. Clinicians reported that identifying TBI may contribute to a richer understanding of personal life history and support person-centred care by embedding individualised needs into future interventions. Early documentation of the injury and related information was also noted to support continuity of personalised care. The adapted OSU TBI-ID was also described as aligning with trauma-informed practice, as improved understanding of individual history may reduce the risk of re-traumatisation and improve understanding of altered reality in future dementia care.

*Callum: "…if…in their timeline was taken back…it's documented, so it's not just something put down to their dementia…I find it quite important to capture that, so it's written down somewhere…"*

*Amy: "…would be really important from a stress and distress point of view…also be relevant because it's a significant part of someone's history and their life story, and they might have distress associated with the thing that caused them the injury and we're gaining information about that that we might not have gotten otherwise"*

## Discussion

The quantitative and qualitative results of this study support the feasibility and usefulness of the adapted OSU TBI-ID in identifying TBI history within older adult dementia assessments. Use of the standardised measurement tool significantly increased the rate of lifetime TBI history being assessed and documented as present or absent and significantly increased the identification rate of positive TBI history. Participants reported consideration of TBI as useful, relevant, feasible, and consistent with routine dementia assessments, and perceived the structured tool as outperforming routine processes and reducing risk of missed information. Participants reported that they may be more likely to consider semi-structured TBI assessments in their future dementia clinics. Participants discussed the subtle, yet meaningful influence TBI consideration may have on understanding individual presentations and life stories, which may inform person-centred care planning such as stress and distress approaches as dementia progresses.

The current findings support improved assessment, documentation, and identification of TBI history when utilising a structured, validated measurement tool over routine, informal methods. This significant increase in positive TBI identification is consistent with literature demonstrating the benefit of structured approaches over informal clinical questioning or brief screens (Gardner et al., 2020; Schneider-Cline, Bush & McKelvey, 2019). A study of older adults with and without MCI found the OSU TBI-ID outperformed a brief screen routinely used in research settings, with the brief measure missing half of positive TBI histories identified by the formal measurement tool (Gardner et al., 2020). Similarly, a study in rural older adults found almost 90% of TBIs identified using the OSU TBI-ID had no prior documentation, and some injuries identified were not recognised by patients to be head injuries prior to assessment (Schneider-Cline, Bush & McKelvey, 2019). This supports participant perceptions in the present study that structured questioning may identify relevant injuries that would otherwise have been missed and limited by lay understanding of what constitutes a TBI. Similar findings have also been reported using different structured methods, such as the comprehensive Brain Injury Screening Questionnaire identifying substantially more positive TBI histories compared to single-item questions (Dams-O'Connor et al., 2014), further supporting initial validation studies of the OSU TBI-ID (Corrigan & Bogner, 2007a). OSU TBI-ID validation studies highlighted the limited research on reliability and validity of brief questioning, despite frequent use within research and clinical practice and the resulting underestimation of TBI history from

single-item screens (Bogner & Corrigan, 2009; Corrigan & Bogner, 2007a). Furthermore, reliance on medical records alone can underestimate lifetime TBI history, as individuals may not seek medical treatment following injury (Corrigan & Bogner, 2007b; Dams-O'Connor et al., 2014), particularly in older adults (Gardner et al., 2020; Schneider-Cline, Bush & McKelvey, 2019).

Previous literature suggests that TBI may be under-recognised in older adults, in clinical and research settings (Depreitere et al., 2025; Sherry et al., 2025), and this is clinically important given the established association between lifetime TBI history and increased dementia risk (Gu, Ou & Liu, 2022; Livingston et al., 2020; Zhang et al., 2021). Given these challenges, reliance on spontaneous self-report, brief informal questioning, or existing documentation alone may fail to identify an important dementia risk factor, supporting the incorporation of structured TBI assessment methods in older adult dementia assessments.

Beyond improved identification and documentation of TBI history, the current findings suggest that structured assessment tools can be feasibly integrated into routine dementia assessments within OA-CMHTs and provide added value to existing processes. Participant feedback suggested that the adapted OSU TBI-ID aligned with formal assessment guidelines that recommend assessments should be holistic, comprehensive, and include consideration of neurological history, comorbidities, and dementia risk factors (NICE, 2018; SIGN, 2023). The inclusion of informants where possible was also reported as beneficial, in line with information gathering through multiple sources advised to support accurate diagnosis and care plans (Galasko, 2013, NICE, 2018; SIGN, 2023). The minimal practical burden reported is in keeping with validation and feasibility studies of the OSU TBI-ID and the frequent use of this measure across various clinical and research settings (Bogner & Corrigan, 2009; Gardner et al., 2020; Schneider-Cline, Bush & McKelvey, 2019). More broadly, structured assessment tools are central to dementia assessments across the care pathway, supporting systematic evaluation of cognitive, neuropsychiatric/behavioural, and psychosocial information such as caregiver wellbeing, and accurate, consistent clinical decision-making (Galvin & Sadowsky, 2012; Sheehan, 2012), and importantly must remain practical and feasible for routine use (Sheehan, 2012). Within this context, the adapted OSU TBI-ID provides a standardised framework for systematically exploring lifetime TBI history and meaningful injury characteristics rather than relying on variable, informal methods (Corrigan & Bogner, 2007a; Gardner et al., 2020) or spontaneous self-reports. This is particularly relevant given previous

findings that older adults did not always recognise previous injuries as TBIs and that these injuries were undocumented prior to use of the OSU TBI-ID (Schneider-Cline, Bush & McKelvey, 2019). Obtaining accurate TBI history without structured support may also be challenging with older adults undergoing dementia assessment due to potential memory difficulties associated with ageing (Grilli & Sheldon, 2022) or cognitive decline (Sheehan, 2012). The adapted OSU TBI-ID therefore provides a practical approach to incorporate a recognised dementia risk factor into routine assessment, aligning with dementia guidelines emphasising biopsychosocial approaches to understanding individual history and presentations, inform diagnosis, and care planning (NICE, 2018; SIGN, 2023).

The qualitative analysis suggested that consideration of TBI history has potentially important implications on formulations and understanding individual presentations, and future care. Clinicians described TBI history as providing richer understanding of cognitive and behavioural profiles, and factors relevant to formulation development. This may be particularly relevant given the potential overlap between the cognitive, behavioural, and neuropsychiatric consequences of TBI and dementia conditions (Al-Rubaie, 2025). However, previous research has also suggested that individuals with dementia and lifetime TBI history may have clinical differences in presentation compared to those without such history, including varying cognitive strengths and weaknesses, behavioural and neuropsychiatric symptomatology, and overall physical health (Bray et al., 2021; Dams-O'Connor et al., 2013; Sayed et al., 2013). For example, greater physical health comorbidities and reduced motor functioning has been described in dementia individuals with TBI history (Dams-O'Connor et al., 2013), as well as increased depression, apathy, and irritability (Bray et al., 2021; Dams-O'Connor et al., 2013). These findings suggest that TBI history may provide important contextual information when interpreting cognitive and behavioural changes within a dementia assessment. Participant interviews indicated that TBI was recognised as relevant to individual clinical presentations, however specific factors associated with such history were not detailed. Given that some studies have suggested TBI history may complicate dementia diagnosis (Bray et al., 2021; Sayed et al., 2013), dementia services may benefit from education regarding the impact on clinical presentation and management in individuals who develop dementia and have a positive TBI history.

Importantly, TBI should not be considered as a singular explanation for cognitive decline or dementia presentation, as not all individuals with lifetime TBI develop dementia (LoBue et al.,

2019). However, the presence and persistent effects of injury may interact with ageing, neurological and vascular vulnerability, and other neurodegenerative processes, contributing to variability in how dementia presents between individuals (Al-Rubaie, 2025; Dams-O'Connor et al., 2013). Complexity in recognising the relationship between TBI and dementia is recognised and reinforces the value of using reliable, validated assessment measures. Pradeep and colleagues (2020) found greater false-positive rates of AD diagnoses in individuals with prior TBI compared to autopsy-confirmed diagnoses, highlighting how neurological history may be relevant when considering differential diagnosis. These researchers did not find an increased likelihood of missed AD (Pradeep et al., 2020), however their results support participant perceptions within the present study, regarding discussions that TBI identification may guide further assessment (such as brain imaging or Neuropsychology referrals), due to increased complexity of the formulation.

The final theme generated from the qualitative analysis aligned with literature on longer-term, person-centred dementia care. Early identification and documentation of TBI history may be increasingly important as dementia progresses in severity and individuals may be less able to provide detailed autobiographical information (Grilli & Sheldon, 2022). Person-centred dementia care models emphasise understanding an individual beyond cognitive impairment, by integrating life history, physical health, wellbeing and psychosocial factors (James & Hope, 2013). Similarly, the Newcastle Model conceptualises stress and distress behaviours in dementia as communicating an unmet need and arising from interactions between biopsychosocial factors rather than neurodegeneration alone (James & Hope, 2013; Medea et al., 2020). Within these frameworks, lifetime TBIs may represent both a biological vulnerability and a potentially significant life event that may contribute to understanding stress and distress behaviours in dementia, should future interventions be required. By supporting clinician understanding of behaviour in the context of personal life history, consideration of TBI may also align with trauma-informed approaches to dementia care. This is particularly relevant where previous traumatic experiences influence an individual's responses to care environments or interactions, as understanding one's life story may support clinicians provide more compassionate care and reduce potential experiences of distress or re-traumatisation (Mackenzie et al., 2020; van der Geugten & Goossensen, 2020)

The present study has several limitations. Although study participants represented a range of disciplines integral to dementia assessments in OA-CMHTs, psychiatrists and OTs were not

recruited to the qualitative analysis, and all participants were from services within a single NHS Health Board. Whilst clinics completed by the above disciplines were quantitatively reviewed, the study was unable to capture their qualitative perceptions on usefulness and feasibility, which may have provided further insight into how head injury may inform diagnostic decision-making and medical management. Additionally, results may not generalise to different memory assessment pathways or service structures. Demographic characteristics beyond professional discipline was not collected, limiting assessment of transferability across clinicians with different demographic characteristics and findings should therefore be interpreted primarily in relation to the professional and service contexts represented in the sample. It was not possible to select participating services randomly and the sample was recruited based on service capacity and availability. Recruitment bias may have been present, as volunteers may have had greater interest in TBI or more favourable attitudes towards structured assessment than non-participants, potentially contributing to the positive nature of the qualitative findings. However, participants also expressed nuanced views and identified limitations, and findings were therefore not uniformly positive. It should also be noted that this study evaluated use of the TBI measurement tool, and it was not possible to verify reported injuries. Whilst adaptations made to the TBI tool were minimal, the adapted version was not independently validated, and the potential impact on measurement validity cannot be excluded. The intervention group also had 0% baseline rates of TBI outcomes, creating substantial scope for improvement and potential floor effects. The magnitude of observed change should therefore be interpreted in the context of the low starting point. In the qualitative analysis, one participant initially raised concerns that use of the TBI tool could encourage overemphasis on brain injury, however subsequently reflected on the tool not aiming to clinically diagnose TBI. These nuances did not contribute to the broader pattern of shared meaning within the dataset and therefore was not represented in the final themes (Braun & Clarke, 2022), however supports the importance of ensuring any assessment tool is used with appropriate guidance and training.

Several strengths of the current study should also be noted. As the study was conducted within routine NHS clinical practice settings, ecological validity was strengthened, and current findings indicate that comprehensive TBI consideration is a gap within older adult dementia assessments although it was recognised as a relevant dementia risk factor. Furthermore, the mixed-methods study design is a key strength in this study. Quantitative analyses demonstrated significant increases in rates of TBI being assessed, documented, and identified as present across a large sample of routine dementia assessments, when the adapted OSU TBI-ID was

introduced; and qualitative analyses provided contextual understanding of these results and how clinicians experienced the implementation of the adapted OSU TBI-ID in terms of feasibility, usefulness and impact.

Despite diagnostic recommendations indicating that TBI should be considered within dementia assessments (Arvanitakis, Shah & Bennett, 2019; Galasko, 2013), there is limited guidance on how to practically implement this, and this remains an area that is often missed or insufficiently addressed in clinical practice. The mixed-method findings of this study therefore provide a practical clinical approach to address these concerns. Integration of quantitative and qualitative results strengthens confidence in the recommendation of the OSU TBI-ID as a clinically useful, feasible, and valued method for older adult clinicians to consider TBI history within dementia settings, which can be readily implemented in NHS GG&C OA-CMHT services.

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## Appendices

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Appendix A1: PRISMA Reporting Checklist

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review. | p.8 |
| **ABSTRACT** | | | |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. | p.9 |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | p.13-14 |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | p.14 |
| **METHODS** | | | |
| Eligibility criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | p.15-17 |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | p.15 |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | p.15, Appendix A2 |
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | p.15 |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | p.16 |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study | p.15-17 |

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| | | were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | |
| | 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | p.16-17 |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | p.16 |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. | p.17 |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | p.15-17 |
| | 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions | n/a |
| | 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | p.16-17 |
| | 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | p.17 |
| | 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | p.17 |
| | 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | p.16-17 |
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | p.17 |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | n/a |
| **RESULTS** | | | |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in | p.18-19 |

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| | | the review, ideally using a flow diagram. | |
| | 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | p.18, Appendix A6 |
| Study characteristics | 17 | Cite each included study and present its characteristics. | p.20-28 |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | p.29-30, Appendix A3, A4 |
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | p.20-28 |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies. | p.29-30, Appendix A3, A4 |
| | 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | p.31-38, Appendix A5 |
| | 20c | Present results of all investigations of possible causes of heterogeneity among study results. | n/a |
| | 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | p.31-32 34, 37-38, Appendix A5 |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | n/a |
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | n/a |

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **DISCUSSION** | | | |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | p.40-43 |
| | 23b | Discuss any limitations of the evidence included in the review. | p.40-43 |
| | 23c | Discuss any limitations of the review processes used. | p.43 |
| | 23d | Discuss implications of the results for practice, policy, and future research. | p.42-43 |
| **OTHER INFORMATION** | | | |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | p.15 |
| | 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | p.15 |
| | 24c | Describe and explain any amendments to information provided at registration or in the protocol. | n/a |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | n/a |
| Competing interests | 26 | Declare any competing interests of review authors. | n/a |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | n/a |

*From:* Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.
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Appendix A2: Search Terms

PubMed: “mild behavioural impairment” OR “mild behavioral impairment” OR “MBI”
PsycINFO: “mild behavioural impairment” OR “mild behavioral impairment”
Scopus: “mild behavioural impairment” OR “mild behavioral impairment”

“MBI” as an acronym was initially planned for all three databases. However, after completing the search with PubMed, most articles identified were irrelevant and unrelated to MBI. This acronym was subsequently removed as a search term from PsycINFO and Scopus.

Filters:
Date was filtered from 2012-Present
Language was filtered as English

Appendix A3: JBI Critical Appraisal Checklist – Detailed Summary

| JBI Items<br>First Author, Publication Year | 1: Was the sample frame appropriate to address the target population? | 2: Were study participants sampled in an appropriate way? | 3: Was the sample size adequate? | 4: Were the study subjects and the setting described in detail? | 5: Was the data analysis conducted with sufficient coverage of the identified sample? | 6: Were valid methods used for the identification of the condition? | 7: Was the condition measured in a standard, reliable way for all participants? | 8: Was there appropriate statistical analysis? | 9: Was the response rate adequate, and if not, was the low response rate managed appropriately? |
|---|---|---|---|---|---|---|---|---|---|
| Mortby et al., 2018 | Yes | Yes | Unclear | Yes | Unclear | Yes | Yes | Yes | Unclear |
| Guan et al., 2022 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Park et al., 2024 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| De Lucia et al., 2025 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Sheilkh et al., 2018 | No | Yes | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Gill et al., 2021 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Yokoi et al., 2019 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Yoon et al., 2023 | No | Yes | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Guan et al., 2024 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Vassilaki et al., 2026 | Yes | Yes | Unclear | Yes | Unclear | Yes | Yes | Yes | Unclear |
| Gosselin et al., 2023 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Unclear | Unclear |
| Guan, Rockwood et al., 2022 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Yes | Unclear |
| Matsuoka et al., 2021 | No | Unclear | Unclear | Yes | Unclear | Yes | Yes | Yes | Unclear |
| Andrews et al., 2018 | Yes | Yes | Unclear | Yes | Unclear | Yes | Yes | Yes | Unclear |

Appendix A4: QUIPS Critical Appraisal Tool – Detailed Summary

| QUIPS Items | QUIPS Sub-item | Yoon et al., 2023 | Guan et al., 2024 | Ghahremani et al., 2025 | Kan et al., 2022 | Yokoi et al., 2019 | Ruthirakuhan et al., 2022 | Ghahremani et al., 2023 | Ismail, Leon et al., 2023 | Ismail et al., 2021 | McGirr et al., 2022 | Ismail, Ghahremani et al., 2023 | Ebrahim et al., 2023 | Sharif et al., 2025 | Guan et al., 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Study Participation | Source of target population | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Method used to identify population | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Recruitment period | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Place of recruitment | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Inclusion and exclusion criteria | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Adequate study participation | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial |
| | Baseline characteristics | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Summary Study participation | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |
| Study Attrition | Proportion of baseline sample available for analysis | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial | Partial |
| | Attempts to collect information on participants who dropped out | No | No | No | No | No | No | No | No | No | No | No | No | No | No |
| | Reasons and potential impact of subjects lost to follow-up | No | No | No | No | No | No | No | No | No | No | No | No | No | No |
| | Outcome and prognostic factor information on those lost to follow-up | No | No | No | No | No | No | Partial | No | No | No | Partial | No | No | No |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Study Attrition Summary | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate | Moderate |
| Prognostic Factor (PF) Measurement | Definition of the PF | Yes | Yes | Yes | Yes | No | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Valid and Reliable Measurement of PF | Yes | Yes | Yes | Yes | Partial | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Method and Setting of PF Measurement | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Proportion of data on PF available for analysis | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Method used for missing data | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | PF Measurement Summary | Low | Low | Low | Low | High | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Outcome Measurement | Definition of the Outcome | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Valid and Reliable Measurement of Outcome | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Method and Setting of Outcome Measurement | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Outcome Measurement Summary | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Study Confounding | Important Confounders Measured | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Definition of the confounding factor | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Valid and Reliable Measurement of Confounders | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Method and Setting of | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |

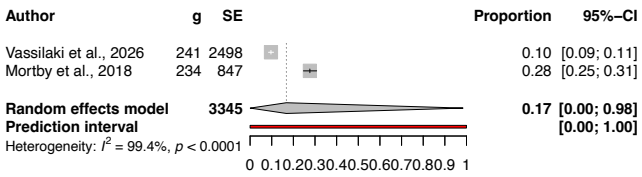
| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Confounding Measurement | | | | | | | | | | | | | | |
| | Method used for missing data | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Appropriate Accounting for Confounding | Yes | Yes | Yes | Yes | Partial | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Study Confounding Summary | Low | Low | Low | Low | Moderate | Low | Low | Low | Low | Low | Low | Low | Low | Low |
| Statistical Analysis and Reporting | Presentation of analytical strategy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Model development strategy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Reporting of results | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| | Statistical Analysis and Presentation Summary | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low | Low |

Appendix A5: Supplementary Meta-Analyses

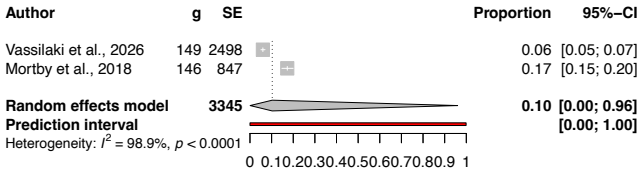
MBI Prevalence in CN Individuals

Two population-based studies (Mortby et al., 2018; Vassilaki et al., 2026) involving 3345 CN individuals were included in a primary prevalence meta-analysis. The third population-based study (Andrews et al., 2018) was excluded due to overlapping datasets. Pooled MBI prevalence was estimated as 16.76% (95% CI 0.07-98.41%, $I^2$=99.4%), with results showing considerable heterogeneity between studies. The estimated pooled prevalence of each domain, from most-to-least frequent was: 10.27% (95% CI 0.05-95.99%) for affect dysregulation, 8.59% (95% CI 0.01-98.46%) for impulse dyscontrol, 2.32% (95% CI 0.29-16.24%) for decreased motivation, 1.17% (95% CI 0.00-99.98%) for social inappropriateness, and 0.20% (95% CI 0.00-99.99%) for abnormal perception/thought. Substantial heterogeneity was observed across MBI domains ($I^2 \geq$71.3%). Sensitivity analyses were not completed for population-based studies as only two studies were available at the overall and domain-level.

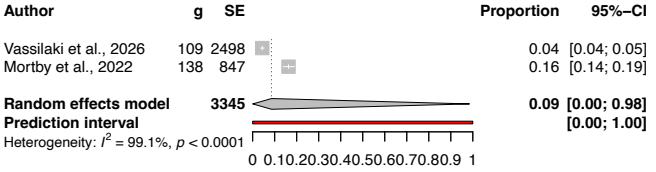
Cognitively Normal – MBI+



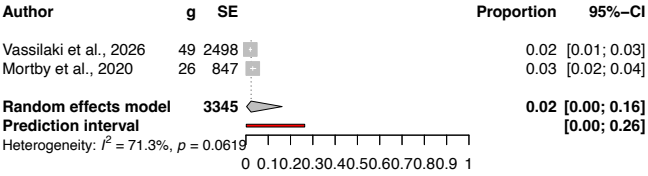

Cognitively Normal – Affect Dysregulation



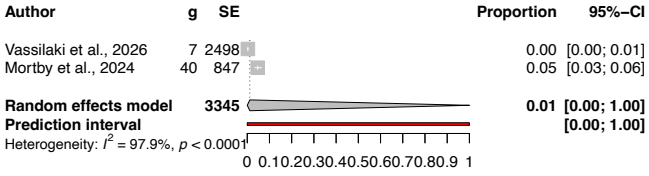

Cognitively Normal – Impulse Dyscontrol




Cognitively Normal – Decreased Motivation




Cognitively Normal – Social Inappropriateness




Cognitively Normal – Abnormal Perception/Thought

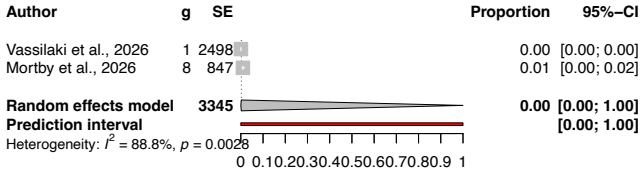



*Figure A5.1: Forest Plots of MBI Overall and Domain-level Estimated Pooled Prevalence in CN Individuals (Primary, Population-based Meta-Analysis)*

Secondary meta-analyses of non-population-based studies were not repeated for supplementary materials as all studies met the ISTAART persistence criterion and were therefore outlined in the main text. The only exception was one study (Gill et al., 2021) which reported on impulse dyscontrol and did not measure persistent MBI symptoms. In the main analysis, the pooled prevalence estimate for impulse dyscontrol was 12.45%, compared to the supplementary meta-analysis which estimated a pooled prevalence of 13.29% for impulse dyscontrol (95% CI 2.71-45.72%). Considerable heterogeneity continued to be shown ($I^2$=95.5%). Sensitivity analyses (i.e., leave-one-out and outlier) demonstrated generally robust prevalence estimates, although caution is warranted given the small number of studies included. The leave-one-out sensitivity analysis showed that excluding individual studies produced only modest changes in the pooled prevalence estimate (ranging from 8.39-19.63%) and did not alter the overall interpretation of

findings. High heterogeneity persisted across all leave-one-out analyses ($I^2$ ≥91.3%), which suggests that between-study variability was not attributable to any single study. The outlier analyses identified Guan et al., (2024) and Matsuoka et al., (2021) as potentially influential studies. Excluding these studies resulted in comparable pooled prevalence estimates, however heterogeneity ($I^2$) reduced to 63.7%. This suggests that although these studies contributed to between-study heterogeneity, they did not have a substantial influence on estimated prevalence of impulse dyscontrol.

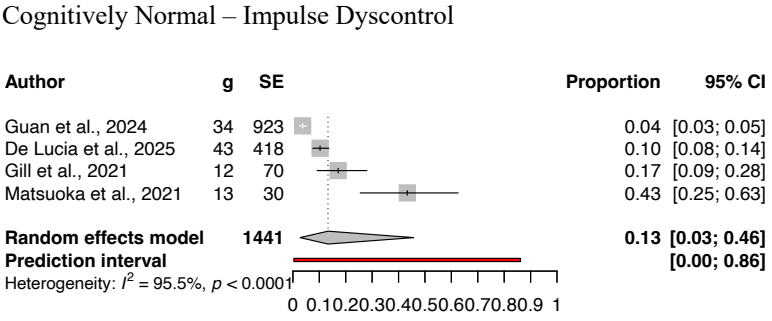



*Figure A5.2: Forest Plot of MBI Impulse Dyscontrol Domain Estimated Pooled Prevalence in CN Individuals (Secondary Meta-Analysis)*

MBI Prevalence in SCD Individuals

In SCD studies, two independent databases were pooled (Ghahremani et al., 2025; Sheikh et al., 2018) for overall MBI prevalence regardless of the ISTAART persistence criterion being met. The pooled overall prevalence was estimated as 42.89% in SCD individuals (95% CI 0.00-100%, $I^2$=99.4%), with considerably heterogeneity limiting results. Sensitivity analyses were not completed due to only two studies being included.

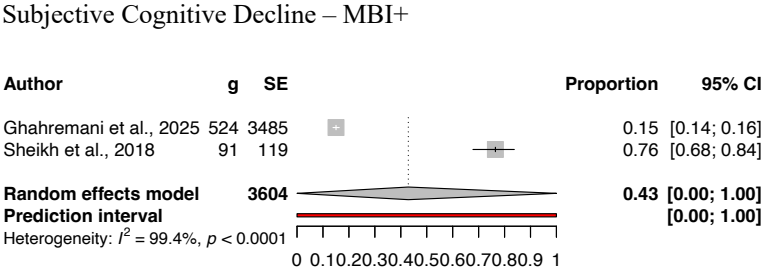



*Figure A5.3: Forest Plot of MBI Overall Estimated Pooled Prevalence in SCD Individuals (Secondary Meta-Analysis)*

MBI Prevalence in MCI Individuals

The same two population-based studies (Mortby et al., 2018; Vassilaki et al., 2026) reporting on CN individuals also described prevalence in MCI, with 348 MCI individuals included in the primary prevalence meta-analysis. The overall pooled prevalence of MBI was 38.10% (95% CI 1.27-96.72%), with considerable heterogeneity between studies ($I^2$=92.8%). Sensitivity analyses were not completed due to limited number of studies, and it was not possible to pool domain-level prevalence as this not being reported in MCI individuals in Vassilaki et al. (2026).

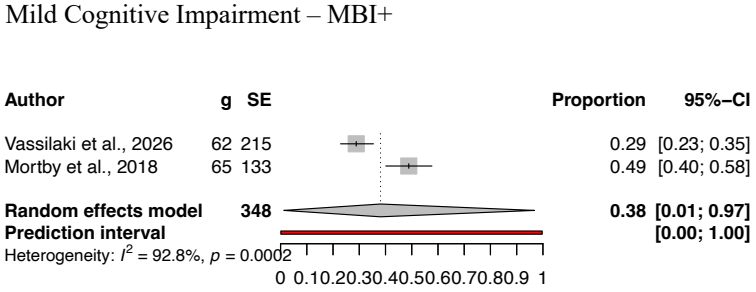
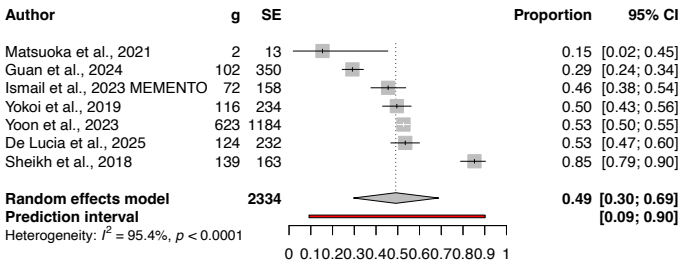



*Figure A5.4: Forest Plot of MBI Overall Estimated Pooled Prevalence in MCI Individuals (Primary, Population-based Meta-Analysis)*

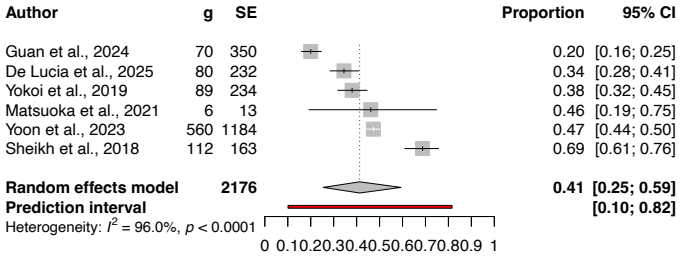
For overall MBI prevalence, a secondary meta-analysis of seven non-population-based studies was completed (Sheikh et al., 2018; Matsuoka et al., 2021; Yoon et al., 2023; Guan et al., 2024; De Lucia et al., 2025; Yokoi et al., 2019; Ismail, Leon et al., 2023-Memento), involving 2334 MCI individuals. Pooled MBI prevalence was estimated as 49.10% (95% CI 29.64-68.83, $I^2$=95.4%) across studies regardless of the persistence criteria. Sensitivity analyses for overall prevalence demonstrated that estimates were generally robust to the exclusion of individual studies. Omitting individual studies resulted in pooled prevalence estimates ranging from 43.62-53.53%, with no meaningful change in interpretation and high heterogeneity remained ($I^2$=92.3-96.2%). This suggests that between-study variability was not attributable to any single study. Outlier analysis identified Sheikh et al. (2018) as a potentially influential study. However, exclusion of this study resulted in a comparable pooled prevalence estimate (43.91% vs. 49.37% in the full analysis), and heterogeneity minimally reduced from 98% to 92.9%. Therefore, although Sheikh et al. (2018) appeared to contribute to heterogeneity, the study did not have a marked influence on the overall prevalence estimate.

For domain-level prevalence, six studies were involved with 1942 MCI individuals (i.e., Ismail, Leon et al., 2023-Memento did not report domain results), however for impulse dyscontrol, one additional study was used (Gill et al., 2021) and a total of 2037 individuals were therefore included for impulse dyscontrol specifically. The pooled prevalence of each domain in MCI individuals was: 41.35% (95% CI 25.41-59.33%) for affect dysregulation, 28.50% (95% CI 17.21-43.31%) for impulse dyscontrol, 21.96% (95% CI 10.23-40.99%) for decreased motivation, 8.06% (95% CI 3.45-17.70%) for social inappropriateness, and 3.11% (95% CI 1.38-6.88%) for abnormal perception/thought. There was substantial heterogeneity between studies across all domains. Abnormal perception/thought was less heterogenous compared to other domains, albeit remained substantial ($I^2$=74.7%, $p$ = .001 compared to $I^2$ ≥93.8%, $p$ < .0001 in remaining domains). Sensitivity analyses (i.e., leave-one-out and outlier) were completed and demonstrated rather robust prevalence estimates across MBI domains. Sequential exclusion of individual studies produced modest changes in pooled prevalence estimates and did not alter the interpretation of findings. No single study substantially influenced heterogeneity, and substantial heterogeneity persisted across domains. Outlier analyses identified Sheikh et al. (2018) as a potentially influential study across domains and Guan et al. (2024) was additionally identified for affective dysregulation. However, exclusion of outliers resulted in comparable prevalence estimates across domains, with changes appearing minimal to modest. Removal of outliers reduced heterogeneity, particularly for affective dysregulation ($I^2$ reduced from 96.88% to 78.46%), and to a greater extent for abnormal perception/thought ($I^2$ reduced from 80.24% to 55.95%). Results from the sensitivity analyses therefore supported the robustness of pooled prevalence estimates while noting ongoing between-study variability.

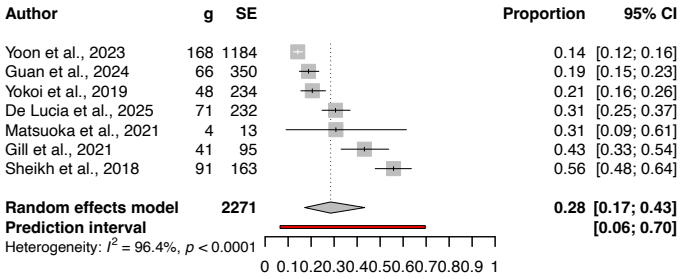
Mild Cognitive Impairment – MBI+



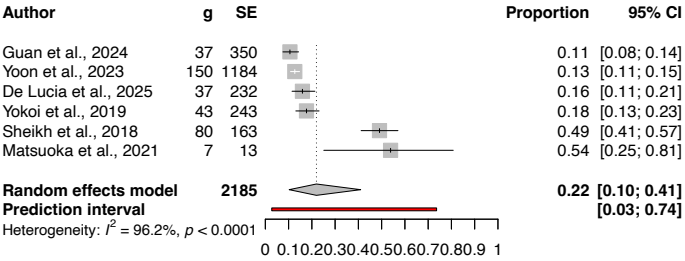
Mild Cognitive Impairment – Affective Dysregulation



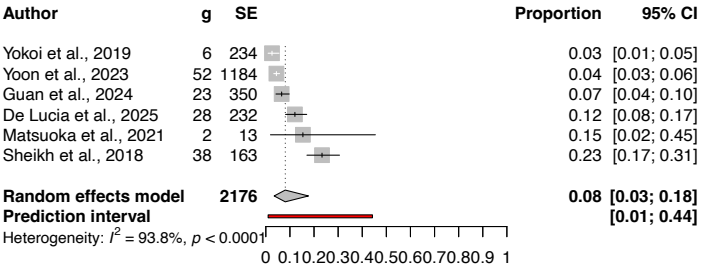

Mild Cognitive Impairment – Impulse Dyscontrol




Mild Cognitive Impairment – Decreased Motivation




Mild Cognitive Impairment – Social Inappropriateness




Mild Cognitive Impairment – Abnormal Perception/Thought

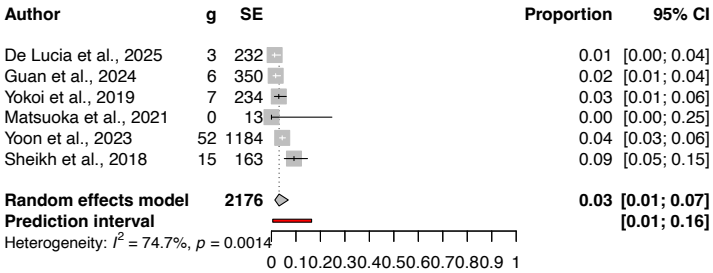



*Figure A5.5: Forest Plot of MBI Overall and Domain-level Estimated Pooled Prevalence in MCI Individuals (Secondary Meta-Analysis)*

*Table A5.1: Summary of Pooled Prevalence of MBI Domains comparing Main Analysis and Supplementary Analysis*

| Main analysis | | | | | |
|---|---|---|---|---|---|
| | Pooled prevalence (95% CI) – Secondary meta-analyses | | | | |
| MBI Domains<br>Population | Affective dysregulation | Impulse dyscontrol | Decreased motivation | Social inappropriateness | Abnormal perception/thought |
| CN<br>(*k*=3) | 13.31%<br>(0.71-76.65%) | 12.45%<br>(0.69-74.49%) | 4.66%<br>(0.20-53.81%) | 1.02%<br>(0.32-3.17%) | 0.29%<br>(0.03-2.46%) |
| MCI<br>(k=3) | 29.02%<br>(11.21-56.97%) | 24.67%<br>(11.69-44.77%) | 20.20%<br>(2.64-70.28%) | 9.20%<br>(3.64-21.40%) | 1.51%<br>(0.36-6.12%) |
| Supplementary analysis | | | | | |
| | Pooled prevalence (95% CI) – Primary Population-based studies, supplementary meta-analysis | | | | |
| MBI Domains<br>Population | Affective dysregulation | Impulse dyscontrol | Decreased motivation | Social inappropriateness | Abnormal perception/thought |
| CN<br>(*k*=2) | 10.27%<br>(0.05-95.99%) | 8.59%<br>(0.01-98.46%) | 2.32%<br>(0.29-16.24%) | 1.17%<br>(0.00-99.98%) | 0.20%<br>(0.00-99.99%) |
| | Pooled prevalence (95% CI) – Secondary studies, supplementary meta-analysis | | | | |
| CN<br>(*k*=3 for all except*) | 13.31%<br>(0.71-76.65%)<br>(*same as main*) | 13.29%<br>(2.71-45.72%)<br>(**k*=4) | 4.66%<br>(0.20-53.81%)<br>(*same as main*) | 1.02%<br>(0.32-3.17%)<br>(*same as main*) | 0.29%<br>(0.03-2.46%)<br>(*same as main*) |
| MCI<br>(*k*=6 for all except*) | 41.35%<br>(25.41-59.33%) | 28.50%<br>(17.21-43.31%)<br>(**k*=7) | 21.96%<br>(10.23-40.99%) | 8.06%<br>(3.45-17.70% | 3.11%<br>(1.38-6.88%) |

MBI Risk to Dementia in CN Individuals

It was not possible to compete a supplementary meta-analysis for overall or domain-level risk to incident dementia in CN individuals due to overlapping datasets within studies.

MBI Incident Risk to Dementia in SCD Individuals

Similarly, it was not possible to complete a supplementary meta-analysis for overall or domain-level risk to incident dementia in SCD individuals as appropriate outcome variables were only available in one study.

MBI Incident Risk to Dementia in MCI Individuals

Overall Risk

A supplementary meta-analysis with four datasets (Ismail, Leon et al., 2023 – Memento and ADNI database; Guan et al., 2024; Yoon et al., 2023) was completed for incident dementia risk

in MCI individuals. This included one additional non-persistent study compared to the main analysis results (i.e., Yoon et al., 2023). The estimated pooled HR of 2.72 (95% CI 1.81-4.09) indicated that MBI was associated with an increased risk of incident dementia in individuals with MCI. Heterogeneity was higher compared to the main analysis ($I^2$=68%, $p$ = .0247 vs. 0%). Leave-one-out sensitivity analyses demonstrated that exclusion of individual datasets resulted in comparable pooled HR estimates, ranging from 2.54HR (95% CI 1.57-4.11) when excluding the ADNI dataset to 3.28HR (95% CI 2.45-4.41) when excluding the non-persistent study, and all leave-one-out estimates remained statistically significant. Outlier analyses using standardised residuals identified Yoon et al. (2023) as a potentially influential dataset (standardised residuals = -3.10), whilst other datasets remained below the predefined threshold of ±2. Heterogeneity following the exclusion of Yoon et al. (2023) reduced to 0% and was consistent with the main analysis where this non-persistent study was not included. This suggests that Yoon et al. (2023) contributed substantially to between-study variability, however its inclusion did not alter the overall interpretation of the association between MBI and incident dementia risk.

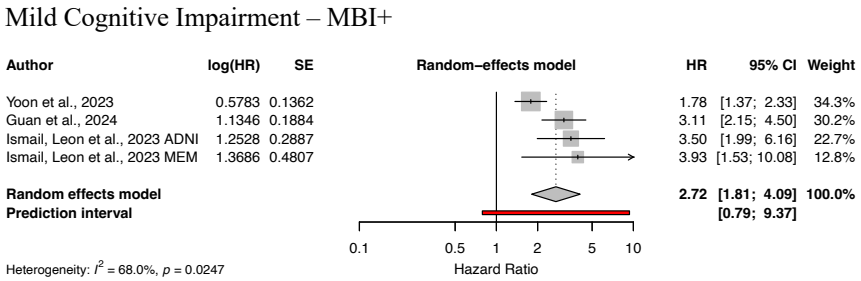



*Figure A5.6: Forest Plot of MBI Overall Estimated Pooled Hazard Ratios in MCI Individuals*

Domain-level Risk

Supplementary meta-analyses were completed using two studies that reported on domain-level associations between MBI and incident dementia risk in MCI individuals (Yoon et al., 2023; Yokoi et al., 2019). Both studies did not meet the ISTAART persistence criterion. Domain-specific HRs were pooled separately as individuals could meet criteria for multiple MBI domains. The pooled HR estimates of each domain were: 1.04 HR (95% CI 0.58-1.87) for affective dysregulation, 1.40 HR (95% CI 0.71-2.74) for impulse dyscontrol, 1.70 HR (95% CI 1.03-2.82) for decreased motivation, 1.65 HR (95% CI 1.08-2.52) for social inappropriateness, and 2.33 HR (95% CI 1.6-3.38) for abnormal perception/thought. Heterogeneity ($I^2$) was 0% for the abnormal perception/thought and social inappropriateness domain, whilst substantial

heterogeneity was reported across the remaining domains ($I^2$ ≥70.1%). Sensitivity analyses were not conducted due to the limited number of studies contributing to each domain-level analysis ($k$=2).

Mild Cognitive Impairment – MBI Domains

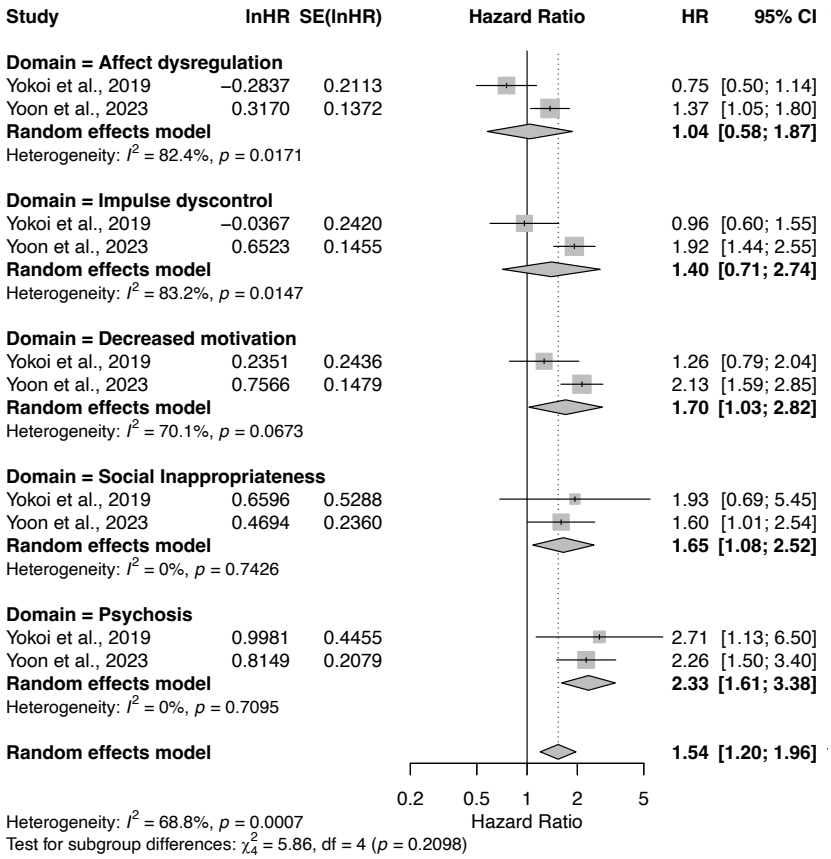



*Figure A5.7: Forest Plot of MBI Domain-level Estimated Pooled Hazard Ratios in MCI Individuals*

*Table A5.2: Summary of Pooled Hazard Ratios for Overall and Domain-level MBI comparing Main Analysis and Supplementary Analysis*

| Main analysis | | | | | | |
|---|---|---|---|---|---|---|
| | Pooled hazard ratios (95% CI) | | | | | |
| MBI Domains<br>Population | MBI+ Overall | Affective dysregulation | Impulse dyscontrol | Decreased motivation | Social inappropriateness | Abnormal perception/thought |
| MCI | 3.28HR (2.45-4.41) (*k*=3) | N/A | N/A | N/A | N/A | N/A |
| Supplementary analysis | | | | | | |
| | Pooled hazard ratios (95% CI) | | | | | |
| MBI Domains<br>Population | MBI+ Overall | Affective dysregulation | Impulse dyscontrol | Decreased motivation | Social inappropriateness | Abnormal perception/thought |
| MCI | 2.72 (1.81-4.09) (*k*=4) | 1.04 (0.58-1.87) (*k*=2) | 1.40 (0.71-2.74) (*k*=2) | 1.70 (1.03-2.82) (*k*=2) | 1.65 (1.08-2.52) (*k*=2) | 2.33 (1.6-3.38) (*k*=2) |

Appendix A6: Main Reason for Excluding Studies at Full-Text Review

| First Author | Publication Year | Main Reason for Exclusion: |
|---|---|---|
| Elefante et al. | 2019 | Wrong outcome |
| Mortby et al. | 2017 | Wrong exposure/intervention |
| Wise et al. | 2019 | Wrong exposure/intervention |
| Gosselin et al. | 2019 | Wrong outcome |
| Vellone et al. | 2022 | Wrong population (age) |
| Bray et al. | 2022 | Wrong outcome |
| Creese et al. | 2023 | Wrong outcome |
| Gracia-García et al. | 2024 | Wrong exposure/intervention |
| Guan, Mortby et al. | 2024 | Wrong outcome |
| Chen et al. | 2025 | Wrong exposure/intervention |
| Angelopoulou et al. | 2025 | Wrong outcome |
| Rouse | 2022 | Wrong study design |
| Hu et al. | 2023 | Wrong outcome |
| Cherkasov & Kolykhalov | 2024 | Wrong outcome |
| Pektaş & Peker | 2025 | Wrong outcome |
| Matsuoka et al. | 2024 | Wrong outcome |
| Rashedi et al. | 2025 | Wrong outcome |
| Kim et al. | 2025 | Wrong outcome |
| Lin et al. | 2025 | Wrong outcome |
| Liew et al. | 2018 | Wrong exposure/intervention |
| Rao et al. | 2020 | Wrong outcome (Prev from MBI+ only) |
| Tsunoda et al. | 2020 | Wrong outcome |
| Aundhakar et al. | 2025 | Wrong outcome |
| Suriyawong et al. | 2025 | Wrong outcome |
| Matsuoka et al. | 2025 | Wrong outcome |
| Mudalige et al. | 2024 | Wrong outcome |
| Taragano et al. | 2018 | Wrong exposure/intervention |
| Saari et al. | 2022 | Wrong outcome |
| Creese et al. | 2020 | Wrong population (dementia measurement) |
| Soo et al. | 2021 | Wrong outcome |
| Richey et al. | 2025 | Wrong population |
| Matsuoka et al. | 2019 | Wrong population |

| | | |
|---|---|---|
| Orso et al. | 2020 | Wrong exposure/intervention |
| Wolfova et al. | 2022 | Wrong outcome |
| Leow et al. | 2024 | Wrong outcome |
| Imai et al. | 2023 | Wrong outcome |
| Mallo et al. | 2018 | Wrong outcome |
| Mallo et al. | 2019 | Wrong outcome |
| Naude et al. | 2020 | Wrong outcome |
| Richey et al. | 2024 | Wrong population |
| Fan et al. | 2020 | Wrong outcome |
| Creese et al. | 2019 | Wrong outcome |
| Kassam et al. | 2023 | Wrong outcome |
| Scheuermann et al. | 2024 | Wrong outcome |
| Tsai et al. | 2023 | Wrong outcome |
| Rouse et al. | 2024 | Wrong outcome (Prev from MBI+ only) |
| Rouse et al. | 2021 | Wrong outcome (Prev from MBI+ only) |
| Kianimehr et al. | 2022 | Wrong outcome |
| Stella et al. | 2022 | Wrong outcome |
| Guan, Mudalige et al. | 2024 | Wrong outcome |
| Warring et al. | 2024 | Wrong population (dementia measurement) |

Appendix B1: GRAMMS Reporting Guidelines

| GRAMMS Reporting Guideline Items | Reported in thesis (page) |
|---|---|
| 1: Describe the justification for using a mixed methods approach to the research question | p.57 |
| 2: Describe the design in terms of the purpose, priority and sequence of methods | p.57, p.58-61, including Table 1 on p.60 |
| 3: Describe each method in terms of sampling, data collection and analysis | p.58-62 |
| 4: Describe where integration has occurred, how it has occurred and who has participated in it | p.74, p.77-78 |
| 5: Describe any limitation of one method associated with the presence of the other method | p.77-78 |
| 6: Describe any insights gained from mixing or integrating methods | p.74, p.78 |

*From:* O'Cathain, A., Murphy, E., & Nicholl, J. (2008). The quality of mixed methods studies in health services research. *Journal of health services research & policy, 13*(2), 92-98.

Appendix B2: MRP Proposal

Final Approved Version: https://osf.io/74ckx/files/sa8yc

Subsequent Revised Version: https://osf.io/74ckx/files/y6urh

Non-substantial Amendment Approval for MRP Proposal

Appendix B3: Ethics Approval Letter

Appendix B4: NHS GG&C Research & Innovation Approval Letter

Appendix B5: Caldicott Guardianship Approval Letter

Appendix B6: Questionnaire Adapted with Permission from the OSU TBI-ID

https://osf.io/74ckx/files/cru7g

Appendix B7: Adaptations Made to the OSU TBI-ID

https://osf.io/74ckx/files/cmydq

Appendix B8: Participant Information Sheet

https://osf.io/74ckx/files/wem4x

Appendix B9: Consent Form Templates

Consent Form: https://osf.io/74ckx/files/smqdr

Optional Consent Form: https://osf.io/74ckx/files/ptmgq

Appendix B10: Semi-Structured Interview Topic Guide

https://osf.io/74ckx/files/c9ekw

Appendix B11: Secondary, Supplementary Analysis

When including psychiatrist assessments, 443 datasets were included in the analysis. In Service 1 (intervention), Time 1 (pre-intervention) included 99 assessments and Time 2 (intervention) included 75 assessments. In Service 2 (control), Time 1 included 186 assessments and Time 2 included 83 assessments.

*Table B11.1: Discipline Count from Secondary, Supplementary Analysis*

| Discipline | Service 1 (N=174) | Service 2 (N=269) |
|---|---|---|
| CPNs | 4 | 82 |
| HCSWs | 57 | - |
| OTs | 14 | - |
| Psychiatrists | 99 | 187 |

Research Question 1a: Does use of an adapted OSU TBI-ID increase the proportion of assessments in which history of TBI is documented and assessed as either present or absent?
At Time 1, three assessments (3.0%) in Service 1 documented the presence or absence of TBI history, whilst 96 assessments (97.0%) did not document TBI history. At Time 2, 24 assessments (32.0%) documented the presence/absence of TBI history, whilst 51 assessments (68.0%) did not. A chi-square test for independence indicated a significant association between Time and Documentation status in Service 1, $\chi^2(1, N = 174) = 25.15$, $p < .001$, $phi = .40$. The phi coefficient value of .40 indicates a medium effect size according to Cohen's (1988) criteria.

In Service 2, results did not indicate a significant association between Time and Documentation status. At Time 1, seven assessments (3.8%) documented the presence/absence of TBI history, whilst 179 assessments (96.2%) did not. At Time 2, four assessments (4.8%) documented TBI history, whilst 79 assessments (95.2%) did not. A Fisher's Exact Test was carried out due to small expected cell counts and no significant association was found, $p = .74$.

At Time 1, two assessments (2.0%) in Service 1 assessed TBI history as either present or absent, whilst 97 assessments (98.0%) did not assess TBI history, informally or with a formal assessment tool. At Time 2, the results for Assessment status were the same as the above-described results for Documentation status (i.e., 32.0% assessed for TBI history). A chi-square

test for independence continued to indicate a significant association between Time and Assessment status in Service 1 ($\chi^2(1, N = 174) = 27.86, p < .001, phi = .42$). The phi coefficient value of .42 indicates a medium effect size.

In Service 2, results remained in keeping with the above-described Documentation status results and the Fisher's Exact Test did not indicate a significant association, $p = .52$.

Research Question 1b: Does use of an adapted OSU TBI-ID lead to an increased number of assessments with TBI history being identified as present?

In Service 1, positive TBI history was not identified prior to the introduction of the adapted OSU TBI-ID in all 99 assessments (i.e., Time 1 = 0%). At Time 2, TBI history was positively identified in 9 assessments (12.0%), whilst the remaining 66 assessments (88.0%) reported absent or unknown TBI history. A Fisher's Exact Test was used and indicated a significant association between Time and Positive TBI history, $p < .001$, $phi = .27$. The phi coefficient value of .27 indicated a small, almost medium, effect size.

In Service 2, six assessments (3.2%) reported a positive lifetime TBI history at Time 1, compared to 180 assessments (96.8%) identifying either absent or unknown TBI history. At Time 2, one assessment (1.2%) reported a positive TBI history, and the remaining 82 assessments (98.8%) identified either absent or unknown histories. Again, the Fisher's Exact Test for Service 2 did not indicate a significant association between Time and Positive TBI history being identified, $p = .44$.

In summary, results from the secondary, supplementary analysis were in keeping with the main findings for the three outcome variables and did not significantly change despite the addition of dementia assessments completed by psychiatrists. When psychiatrists were included in the analysis, the sample size was considerably larger, and effect sizes found were in the medium (for documentation and assessment status) to small range (for positive TBI history).

*Table B11.2: Summary of Quantitative Results from Secondary, Supplementary Analysis*

| RQ and Outcome Variable | Service (1=Interv.) (2=Control) | Time 1 n (%) | Time 2 n (%) | Stats. Test | Test Stats. Result | *p* value | Effect size |
|---|---|---|---|---|---|---|---|
| RQ1a: Documented | 1 | 3 (3.0%) documented | 24 (32.0%) documented | $\chi^2$ | $\chi^2(1, N = 174) = 25.15$ | <.001 | .40 (medium) |
| | 2 | 7 (3.8%) documented | 4 (4.8%) documented | Fisher's Exact | - | .742 | .03 |
| RQ1a: Assessed | 1 | 2 (2.0%) assessed | 24 (32.0%) assessed | $\chi^2$ | $\chi^2(1, N = 174) = 27.86$ | <.001 | .42 (medium) |
| | 2 | 7 (3.8%) assessed | 4 (4.8%) assessed | Fisher's Exact | - | .523 | .04 |
| RQ1b: Presence of TBI history | 1 | 0 (0%) positive TBI identified | 9 (12.0%) positive TBI identified | Fisher's Exact | - | <.001 | .27 (small) |
| | 2 | 6 (3.2%) positive TBI identified | 1 (1.2%) positive TBI identified | Fisher's Exact | - | .443 | -.06 |

RQ: Research Question; Interv.: Intervention service; n: number; %: percentage; $\chi^2$: chi-square test of independence; TBI: traumatic brain injury

Appendix B12: Additional Quotations

| Theme A: Compatible with existing assessment | |
|---|---|
| Subtheme: | Quotations: |
| A1: Perceived burden exceeds actual burden | *Amy: "It's easy to follow and it's short enough that you can include it because there's a lot to include in our first appointments"* |
| | *Matthew: "…a bit of context…we are stratified as red at present…we've got a big staff shortfall…and understandably there is staff feeling very stressed and it could literally be a tick to something and they think oh my god how could I do anything extra…"* |
| | *James: "…nurses get bombarded with more and more paperwork, doctors get more and more paperwork to do in response to these things that could be achieved better by reviewing processes and just changing things…I think in terms of assessment, with this, yes it's an extra piece, but it's something that's actually genuinely helpful, as opposed to something that is there to address a concern that's not really warranted…I would argue probably just being a bit more regimented in asking the question you've probably already been asking anyway…"* |
| A2: Limitations and challenges are not unique to TBI | *Amy: "…it would be the specifics like how long they lost consciousness, they might remember that they had a head injury…but not knowing how long for or having the specific details around that just because of the length of their life…"* |
| Theme B: Benefits beyond existing assessments | |
| B1: Reduces risk of missed information | *Helen: "…they wouldn't think about it… they maybe haven't remembered or haven't thought it was significant…"* |
| | *Robert: "…the person that did answer no then yes…they didn't really think about that when it was a more broad question because I suppose she wasn't really classing that as a head injury…so the questions was helpful just to steer that a little bit more"* |
| B2: Utility over routine, informal methods | *Amy: "…normally I just ask has someone had a bump to the head or something general…if they say yes I would give some kind of questioning around that but not to the details included in the questionnaire like consciousness and things…"* |

| | |
|---|---|
| | *Joanna: "…it's not something I routinely ask…" "…it does go into a bit more detail than maybe you would without those prompts…* |
| B3: May influence future practice | *James: "…maybe now I probably think about that, I might actually just check in with them on sort of the head injuries…"* |
| | *Amy: "…it could be really helpful, like I probably will start using it…don't know if I will start using it routinely…I would use it as a prompt…"* |
| Theme C: Subtle yet meaningful influence on clinical understanding | |
| C1: Linking injury characteristics to presentation | *Alice: "…timeline…an overall formulation of vulnerable brain…it would always be relevant to have that information and be able to match it up with whatever you're seeing and the other bits of information that you have"* |
| | *Robert: "…is it that we're seeing the cognitive deficits linked to that initial injury, whether there was screening done at that point, do we have a baseline that we can compare back to, what services were involved, is what we're seeing now a static impairment linked to that injury or is there further progression…really helpful to say that we're ruling out dementia…but actually it seems its more linked to the brain injury that you had…we'll repeat in 12 months' time just to be absolutely sure…clarity around the impact of that head injury on current presentation…"* |
| | *Vanessa: "…knowing when the change happened…is it related, is it not…"* |
| Theme D: Subtle yet meaningful context for care | |
| D1: could inform immediate and future care plans | *Robert: "you're thinking, alright, okay, did they have any scans back then…further investigations…what is actually the cause…"* |
| | *Alice: I suppose if the formulation was the person's presentation was highly likely because of these repeated brain injuries than say this other type of dementia then that would help us in terms of prognosis and management and so yeah I guess it would in that sense… if you're thinking Newcastle formulation and all the information that goes into that, I think the more information the better"* |

| | |
|---|---|
| D2: Personalised care by embedding personal history | *Matthew: "…I think it would be more positive because you'd know more about the person automatically…it would help build in their life story…"* |
| | *Alice: "…we just have a better sense of them and their life story"* |

Appendix B13: Data Availability Statement

In keeping with the approved Data Management Plan (Proposal Appendix 1), quantitative data created involved excel spreadsheets with collated patient data from health record assessment letters, clinic notes, and scanned copies of uploaded adapted OSU TBI-ID questionnaires. Qualitative data generated consisted of audio interview recordings and verbatim transcripts. Given ethical and privacy concerns regarding the sensitive nature of generated data and given that participants did not consent to sharing of identifiable data with third parties, these datasets will not be made publicly available. Complete datasets (excel spreadsheets of clinical patient data and word documents of interview transcripts) will be stored on the University of Glasgow secure server for 10 years now that the study is complete. This data will be password protected and only accessible by the chief investigator. Data will be deposited in and shared through the University of Glasgow's Enlighten Data Repository system and pseudonymised findings will be summarised and disseminated through academic publication.

Appendix B14: Data Analysis Plan

https://osf.io/74ckx/files/b7vx9

Appendix B15: Detailed Record of Data Analysis Process

https://osf.io/74ckx/files/zudw8

Appendix B16: Reflexivity Statement

At the start of the research process, I reflected on my motivations for undertaking this study and the potential ways in which my personal and professional experiences may influence the research process. My interest in dementia research has been shaped by both personal experiences of knowing individuals with dementia and professional experiences working within neuropsychology and older adult services. These experiences have developed a strong personal motivation and professional interest in improving our understanding of dementia and post-diagnostic care.

Throughout the project, I remained aware that these prior experiences and interests may have influenced both data collection and interpretation. During the qualitative interviews, I was particularly mindful of my expectation that clinicians might perceive the adapted assessment tool as useful. I therefore adopted an open and exploratory interviewing style, encouraging participants to discuss both positive and negative experiences of using the tool, and allowing discussion to extend beyond the interview topic guide.

Additionally, as a trainee who subsequently went onto completing a placement within one of the participating services, I also recognised that my position may have influenced the research process. Some interview participants were colleagues that I was not directly working with however were members of the same multidisciplinary team, and one participant was a supervising clinician that I worked with (although most participants were clinicians that I had no prior working relationship with). I reflected on the way existing professional relationships may have influenced the way participants and I interacted with each other and tried to minimise bias by engaging with all participants in the same manner throughout the research process. Additionally, it was emphasised that participation was entirely voluntary, and confidentiality was emphasised throughout, including reminding participants that their responses would be pseudonymised and personally identifiable information and personal disclosures would be redacted. This was partly intended to reassure participants that taking part in the study would not influence professional working relationships, for example.

Reflexivity was maintained throughout the data collection and analysis process. For example, reflective notes were taken during familiarisation, coding, and theme development of the qualitative data to document assumptions, alternative interpretations, and analytical decisions.

Regular discussions with research supervisors also provided opportunities to challenge my interpretations and ensure that themes remained grounded in participant accounts rather than my own expectations. As some quantitative analyses were completed prior to the qualitative interviews, this was helpful in providing some context of real clinical data. However, I was careful to minimise the possibility that findings from the preliminary quantitative analyses influenced the qualitative interviews or subsequent interpretation of participant accounts.

I recognised that my clinical interests and experiences have inevitably shaped the way I approached this research. Therefore, rather than attempting to eliminate this influence, I aimed to acknowledge this and conduct the research in a transparent and reflexive manner through ongoing self-reflection, use of supervision, and careful engagement with both the quantitative and qualitative data.