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Economic, cognitive, and behavioural dimensions of medication non-adherence and their association with blood-pressure control among rural Bangladeshi adults with hypertension: a cross-sectional analysis

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Additional Declarations: Competing interest reported. The authors developed the BMAS instrument used in this study; they declare no other competing interests.

Abstract

Background

Medication non-adherence is multidimensional, yet adherence scales are usually analysed as a single total score, obscuring which type of barrier — economic, cognitive, or behavioural — is most burdensome and which actually relates to disease control. Using the three dimensions of the validated Bangladesh Medication Adherence Scale (BMAS), we examined, among rural Bangladeshi adults with hypertension, the relative burden of each barrier dimension, its association with blood-pressure (BP) control, and its sociodemographic distribution.

Methods

Cross-sectional analysis of 461 hypertensive adults (analytic N = 446) from a community-based survey in Kamalganj, north-east Bangladesh. The 9-item BMAS yields three 3-item subscales — economic, cognitive (memory-related/unintentional), and behavioural (deliberate/intentional); higher scores denote fewer barriers. Barrier burden was compared with the Friedman test; associations with BP control (systolic BP < 140 and diastolic BP < 90 mmHg) and with systolic BP were tested by logistic and linear regression adjusted for age, gender, socioeconomic status (SES), education, body-mass index and diabetes; sociodemographic distribution was assessed with adjusted linear regression.

Results

Subscale reliability was acceptable-to-excellent (Cronbach's α .73–.90). Barrier burden differed significantly across domains (Friedman $\chi^2(2) = 234.45$, $p < .001$): economic barriers were the most severe (5.31 ± 2.72 of 9), then cognitive (6.75 ± 1.85), then behavioural (7.45 ± 1.81); the three most severely endorsed items were all economic. Despite this, economic barriers were not associated with BP. Only the cognitive dimension independently predicted BP control (adjusted odds ratio 1.14 per point, 95% CI 1.01–1.29, $p = .037$) and systolic BP (B = − 1.36 mmHg per point, $p = .019$); economic and behavioural barriers were null (all variance inflation factors < 1.5). Economic barriers were strongly socioeconomically patterned (SES $\beta = .36$, education $\beta = .16$; $R^2 = .20$), whereas cognitive barriers increased and behavioural barriers decreased with age.

Conclusions

The most burdensome barrier — economic, concentrated in poorer patients — was not the one linked to control; the less-burdensome cognitive (memory) barrier, concentrated in older patients, was. Adherence support should be dimension- and patient-specific: financial protection for the socioeconomically

disadvantaged, and memory-focused strategies for older patients, in whom the control-relevant barrier concentrates.

Background

Hypertension is the leading modifiable cause of cardiovascular disease worldwide, and its burden is concentrated in low- and middle-income countries (LMICs) [1, 2]. In Bangladesh, only about one third of treated adults reach target blood pressure despite the wide availability of first-line antihypertensive medicines, and control is poorest in rural areas [2, 3]. Medication adherence is a central, modifiable determinant of this treatment-to-control gap [4, 5], sustained by a range of patient- and provider-level barriers to obtaining, taking and continuing treatment [17].

Adherence, however, is not a single behaviour. Contemporary frameworks distinguish several dimensions — including practical/economic barriers to obtaining medicines, unintentional lapses driven by forgetting and memory, and intentional decisions to alter or stop treatment [6, 7, 8]. The distinction between unintentional (cognitive) and intentional (behavioural) non-adherence is well established and has different remedies: reminders and adherence aids for the former, and belief-focused counselling for the latter [7, 8, 9]. Yet most adherence instruments are summed into a single score, and most studies relate only that total to outcomes, obscuring which dimension is most burdensome for patients and which actually translates into poorer disease control. But the two need not be the same. A barrier can be widely felt yet not be what actually keeps blood pressure uncontrolled. Knowing which dimension drives poor control — and which patients it affects most — is what allows adherence support to be targeted.

The Bangladesh Medication Adherence Scale (BMAS) is a locally developed, validated 9-item instrument with a three-factor structure — economic, cognitive, and behavioural — each represented by three items [10]. It therefore permits a dimension-specific analysis that a total score cannot. To date, no study has used these dimensions to ask which type of adherence barrier is most burdensome in a hypertensive population, which is associated with achieved BP control, and how each is distributed across patients.

We conducted a pre-planned secondary analysis of the quantitative dataset from our community-based study of hypertension self-management in rural Bangladesh [11]. Whereas the parent study used only the total BMAS score (and a belief-based mediation model), the present analysis decomposes adherence into its three barrier dimensions and addresses three objectives: (i) to quantify and rank the burden of economic, cognitive and behavioural barriers; (ii) to determine which dimension is independently associated with BP control; and (iii) to describe the sociodemographic distribution of each dimension.

Methods

Design and setting

This is a cross-sectional analysis of the quantitative phase of a community-based study conducted in Kamalganj sub-district, Moulvibazar district, north-east Bangladesh (December 2025–February 2026);

the full protocol and primary findings are reported in the companion study [11]. Reporting follows the STROBE guidance for cross-sectional studies [12].

Participants

Community-dwelling adults (≥ 18 years) with previously diagnosed hypertension prescribed antihypertensive medication were eligible; those with severe physical or cognitive impairment precluding interview were excluded. Of 501 eligible adults approached, 461 (92.0%) consented and completed face-to-face interviews conducted by computer-assisted personal interviewing on the REDCap electronic data-capture platform. Fifteen participants were not taking any antihypertensive medication at the time of interview, so the BMAS — a measure of medication-taking behaviour — could not be scored for them; they were excluded, yielding an analytic sample of 446 for the subscale analyses.

Exposure: adherence-barrier dimensions

Adherence was measured with the validated 9-item BMAS (each item scored 0–3; higher = better adherence/fewer barriers) [10]. Its three factors were scored as 3-item subscales (range 0–9): **Economic** (items 6, 7, 9 — affording and purchasing medicines), **Cognitive** (items 1, 2, 5 — forgetting, mistiming and difficulty remembering; predominantly unintentional non-adherence), and **Behavioural** (items 3, 4, 8 — deliberately stopping or self-adjusting the regimen; intentional non-adherence). Item content within a factor is empirically defined; one behaviourally flavoured item (item 2, 'not taking medication on time') loads statistically with the memory items and is retained in the cognitive subscale.

Outcomes and covariates

Blood pressure was measured with a validated automated device (OMRON HEM-7120), averaging two readings after ≥ 5 minutes' rest; BP control was defined as systolic BP < 140 mmHg and diastolic BP < 90 mmHg, consistent with contemporary guideline thresholds [16]. Outcomes were BP control (binary) and mean systolic BP (continuous). Covariates were age, gender, household socioeconomic status (modified Kuppuswamy scale adapted for use in Bangladesh, three categories) [13], educational attainment (three categories), body-mass index (BMI) and diabetes.

Statistical analysis

Internal consistency of each subscale was assessed with Cronbach's α. Because the three subscales share a 0–9 metric with three items each, within-person differences in barrier burden were tested with the Friedman test and Kendall's W. The independent association of each barrier dimension with BP control was tested by entering the three subscales together in a binary logistic regression (and a linear regression on systolic BP), adjusting for age, gender, SES, education, BMI and diabetes; multicollinearity was assessed with variance inflation factors (VIF). Item-level differences by control status were

examined with independent-samples t-tests (exploratory). The sociodemographic distribution of each dimension was assessed with separate linear regressions of each subscale on age, gender, SES and education. Because the three barrier dimensions were pre-specified hypotheses, subscale models were not adjusted for multiple comparisons; item-level t-tests are exploratory and interpreted as hypothesis-generating. Analyses used IBM SPSS Statistics version 31; two-sided α = 0.05.

Ethics

The study was approved by the Institutional Review Board of Bangladesh Medical University (BSMMU/2023/6516; addendum BMU/2025/14636(A)). Written informed consent to participate was obtained from all participants.

Results

Barrier burden and reliability

Full sociodemographic and clinical characteristics of the source cohort are reported in the companion study [11]; the present subscale analyses used the 446 participants with complete BMAS data. Among these 446 participants, the three barrier subscales showed acceptable-to-excellent internal consistency (economic α = .90; cognitive α = .75; behavioural α = .73). Barrier burden differed markedly across domains (Friedman $\chi^2(2) = 234.45$, $p < .001$, Kendall's W = .263): economic barriers were the most severe, followed by cognitive and then behavioural (Table 1, Fig. 1). At the item level, the three most severely endorsed barriers in the entire scale were all economic — difficulty affording medication, medicines being too expensive, and being unable to buy on time for financial reasons (Table 2).

Table 1 Barrier subscale reliability, burden and within-person ranking

Barrier domain (items)	Cronbach's α	Mean ± SD (0–9)	Friedman rank
Economic (6, 7, 9)	.90	5.31 ± 2.72	1.51
Cognitive (1, 2, 5)	.75	6.75 ± 1.85	2.07
Behavioural (3, 4, 8)	.73	7.45 ± 1.81	2.42

Higher score / rank = fewer barriers. Friedman $\chi^2(2) = 234.45$, $p < .001$, Kendall's W = .263 (Economic < Cognitive < Behavioural).

Table 2 Item-level barrier burden

Item	Domain	Mean ± SD
6. Spending money on medications is difficult for me	Economic	1.68 ± 0.99
9. Buying medication is difficult for me because they are expensive	Economic	1.72 ± 1.01
7. When my medication finishes, I cannot buy it on time due to financial problems	Economic	1.91 ± 0.97
5. I have difficulty remembering to take all my medications	Cognitive	2.16 ± 0.80
2. I do not take my medication on time	Cognitive	2.22 ± 0.68
1. I forget to take my medication	Cognitive	2.37 ± 0.78
4. When I feel better, I stop taking my medication on my own	Behavioural	2.32 ± 0.82
8. I change the dose, amount, or timing of my medication on my own	Behavioural	2.35 ± 0.83
3. When I feel unwell, I stop taking my medication without informing my doctor	Behavioural	2.78 ± 0.57

Values are mean ± SD; 0 = severe barrier, 3 = no barrier. Items ordered most→least severe.

Association of barrier dimensions with blood pressure

Despite economic barriers being the most prevalent, they were not associated with blood-pressure outcomes. In multivariable models adjusting for age, gender, SES, education, BMI and diabetes, the cognitive (memory-related) dimension was the only barrier type independently associated with both a greater likelihood of BP control (adjusted OR 1.14 per point, 95% CI 1.01–1.29, p = .037) and lower systolic BP (B = −1.36 mmHg per point, 95% CI −2.49 to −0.22, p = .019); economic and behavioural barriers were null in both models, and collinearity was acceptable (all VIF < 1.5) (Table 3, Fig. 2). At the item level, difficulty remembering to take medications (item 5, p = .005) was the single item most strongly differentiating controlled from uncontrolled patients, with the other cognitive items directionally consistent; one economic item (item 6, 'Spending money on medications is difficult for me') differed at the unadjusted item level but its association did not persist in the adjusted subscale model (Table 4).

Table 3 Adjusted associations of barrier subscales with BP outcomes (N = 446)

Panel A — Logistic regression, outcome = BP control

Barrier subscale	aOR	95% CI	p
Economic	1.02	0.94–1.11	.66
Cognitive	1.14	1.01–1.29	.037
Behavioural	0.98	0.86–1.11	.73

Panel B — Linear regression, outcome = mean systolic BP

Predictor	B	95% CI	β	p	VIF
Economic	0.01	−0.78 to 0.81	.00	.97	1.45
Cognitive	−1.36	−2.49 to −0.22	−.13	.019	1.37
Behavioural	−0.16	−1.34 to 1.03	−.01	.80	1.44
Age (per year)	0.25	0.11 to 0.39	.18	<.001	1.26

aOR per 1-point (fewer barriers). Both models adjusted for age, gender, SES, education, BMI, diabetes. Logistic: $\chi^2(11) = 12.65$, $p = .32$, Nagelkerke $R^2 = .038$. Linear: $R^2 = .081$, $F(9,436) = 4.26$, $p < .001$. Negative B for cognitive = fewer memory barriers → lower BP.

Table 4 Item-level barrier scores by BP control status (independent t-tests, exploratory)

Item (domain)	Uncontrolled	Controlled	p	d
Item 1 (Cognitive)	2.31 ± 0.79	2.45 ± 0.76	.072	−.17
Item 2 (Cognitive)	2.17 ± 0.69	2.29 ± 0.67	.073	−.17
Item 5 (Cognitive)	**2.07 ± 0.81**	**2.29 ± 0.78**	**.005**	**−.27**
Item 6 (Economic)	**1.60 ± 0.99**	**1.80 ± 0.97**	**.036**	**−.20**
Item 7 (Economic)	1.91 ± 0.99	1.90 ± 0.95	.922	.01
Item 9 (Economic)	1.67 ± 1.03	1.79 ± 0.99	.222	−.12
Item 3 (Behavioural)	2.80 ± 0.58	2.77 ± 0.56	.593	.05
Item 4 (Behavioural)	2.29 ± 0.87	2.35 ± 0.76	.448	−.07
Item 8 (Behavioural)	2.29 ± 0.86	2.42 ± 0.78	.100	−.16

Two-sided p; Cohen's d. Controlled patients report fewer barriers. Significant items in bold. Unadjusted/exploratory. Full item wordings are given in Table 2.

Distribution of barrier dimensions across patients

The barrier dimensions were distributed differently across patient groups (Table 5, Fig. 3). Economic barriers were strongly and independently socioeconomic, predicted by SES (β = .36, p < .001) and education (β = .16, p = .001) and explaining 20% of variance, concentrating in the poorest and least-educated patients. Cognitive and behavioural barriers had weaker sociodemographic patterning (R^2 = .06 and .05) but showed a notable and opposite age effect: older patients reported more cognitive (memory) barriers (β = −.11, p = .034) yet fewer behavioural/intentional barriers (β = +.14, p = .006). No dimension was driven by gender, apart from a small behavioural advantage for women.

Table 5 Independent sociodemographic predictors of each barrier domain (standardized β, p)

Predictor	Economic	Cognitive	Behavioural
Gender (female)	−.03 (.57)	.07 (.16)	.10 (.033)
Age	−.04 (.37)	−.11 (.034)	.14 (.006)
Education	.16 (.001)	.10 (.045)	.10 (.044)
SES	.36 (<.001)	.14 (.004)	.14 (.004)
Model R^2	.20	.06	.05

Values are standardized β (p); each column is a separate linear regression of one subscale on age, gender, SES and education (N = 446; all VIF < 1.25). Positive β = fewer barriers with that predictor. Note the opposite age effects for cognitive vs behavioural barriers.

Discussion

Decomposing medication adherence into its economic, cognitive and behavioural dimensions revealed a three-way dissociation between how burdensome a barrier is, how it is distributed, and whether it relates to disease control. Economic barriers were by far the most burdensome and were strongly concentrated in socioeconomically disadvantaged patients, yet were not independently associated with achieved BP control. The less-burdensome cognitive (memory-related) barrier, concentrated in older patients, was the only dimension linked to control. Using a single total score — the usual approach, and the one used in the parent study — would have hidden all three of these patterns.

That economic barriers dominated the burden hierarchy is consistent with the qualitative findings of the parent study and with cost-related non-adherence widely reported across LMICs [4, 14]. Their lack of independent association with BP, however, is telling. Several explanations are plausible: the cross-sectional design captures point-in-time barriers and a single-visit BP; the effect of cost may be partly buffered by intermittent purchasing or by free first-line medicines at public facilities; and the weak affordability effect seen for a single item disappeared once socioeconomic status was taken into account in the adjusted model, indicating that the economic barrier is closely tied to socioeconomic status and does not act on blood-pressure control on its own.

In contrast, the cognitive dimension — forgetting, mistiming and difficulty remembering — was the only barrier independently associated with both BP control and systolic BP, and the item 'difficulty remembering to take all medications' was the single strongest correlate of control. This is mechanistically coherent: unintentional, memory-driven omission directly interrupts daily dosing in a way that shows up as higher blood pressure, and it is exactly the barrier that responds best to simple, scalable interventions — reminders, fixed-dose combinations, pillboxes and simplified regimens [8, 9, 15]. The finding also fits the established intentional/unintentional framework [7]: unintentional (cognitive) non-adherence was tied to control, whereas intentional (behavioural) self-discontinuation was both uncommon and unrelated to outcome in this treated cohort.

The dimensions were also distributed along different patient axes, which sharpens the targeting message. Economic barriers were steeply socioeconomic (SES β = .36), making them as much an equity issue as an adherence one, so that improving adherence for these patients also means addressing the wider social and economic conditions that shape health [18]. Cognitive barriers rose with age while behavioural barriers fell with age — older patients forgot more but were more disciplined about not self-discontinuing. Because the memory barrier — the one linked to control — is most common in older patients, memory aids can be aimed at the group where they are most likely to improve blood pressure, while financial support tackles the biggest burden felt by poorer patients.

Taken together, these findings argue for dimension- and patient-specific adherence support rather than a one-size-fits-all approach: financial protection for the socioeconomically disadvantaged to relieve the greatest felt burden and an equity gap, and memory-focused strategies for older patients to target the barrier actually associated with blood-pressure control.

Strengths and limitations

Strengths include the use of a locally developed, validated multidimensional adherence instrument analysed at the dimension level (a decomposition rarely undertaken), a community-based sample with a high response rate, standardised BP measurement, and the joint modelling of the three dimensions with acceptable collinearity. Limitations include the cross-sectional design, which precludes causal or temporal inference; reliance on self-reported adherence; single-occasion BP measurement; and the modest overall predictive power of the BP-control model (which did not reach significance), so that the cognitive–control association is best regarded as modest and hypothesis-generating — though its replication across both the binary control and continuous systolic-BP outcomes strengthens it. Finally, the cognitive subscale contains one behaviourally flavoured item ('not taking on time') that loads empirically with the memory items; the wording of individual items in short multidimensional scales does not always fit neatly under a single label.

Conclusions

Among rural Bangladeshi adults with hypertension, the most burdensome adherence barrier — economic, concentrated in poorer patients — was not the one associated with blood-pressure control, whereas the less-burdensome cognitive (memory) barrier, concentrated in older patients, was. Analysing adherence by its dimensions, rather than as a single score, reveals actionable heterogeneity: adherence support should be tailored to the barrier and the patient, combining financial protection for the disadvantaged with memory-focused strategies for older patients.

Abbreviations

aOR adjusted odds ratio; **BMAS** Bangladesh Medication Adherence Scale; **BMI** body-mass index; **BP** blood pressure; **CI** confidence interval; **LMIC** low- and middle-income country; **SES** socioeconomic status; **VIF** variance inflation factor.

Declarations

Ethics approval and consent to participate

Approved by the IRB of Bangladesh Medical University (BSMMU/2023/6516; addendum BMU/2025/14636(A)). Written informed consent to participate in the study was obtained from every participant prior to enrolment; the study conformed to the Declaration of Helsinki.

Consent for publication. Not applicable.

Availability of data and materials. The datasets analysed are available from the corresponding author on reasonable request.

Competing interests. The authors developed the BMAS instrument used in this study; they declare no other competing interests.

Use of large language models: The authors used a large language model (Anthropic Claude) for language editing and to assist in preparing data figures from their own analysed data. All outputs were reviewed and verified by the authors, who take full responsibility for the content. No AI tool is listed as an author.

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Authors' contributions. MTI conceived and designed the study, contributed to data acquisition, performed the statistical analysis, interpreted the results and drafted the manuscript. SMA contributed to the conception and design of the study, provided clinical supervision and critically revised the manuscript for important intellectual content. MAH contributed to the study design and methodology,

advised on and verified the statistical analysis, and critically revised the manuscript for important intellectual content. MKU contributed to the development and psychometric interpretation of the adherence measure, advised on methodology, and critically revised the manuscript for important intellectual content. All authors had full access to the study data, read and approved the final manuscript, and agree to be accountable for all aspects of the work.

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Figures

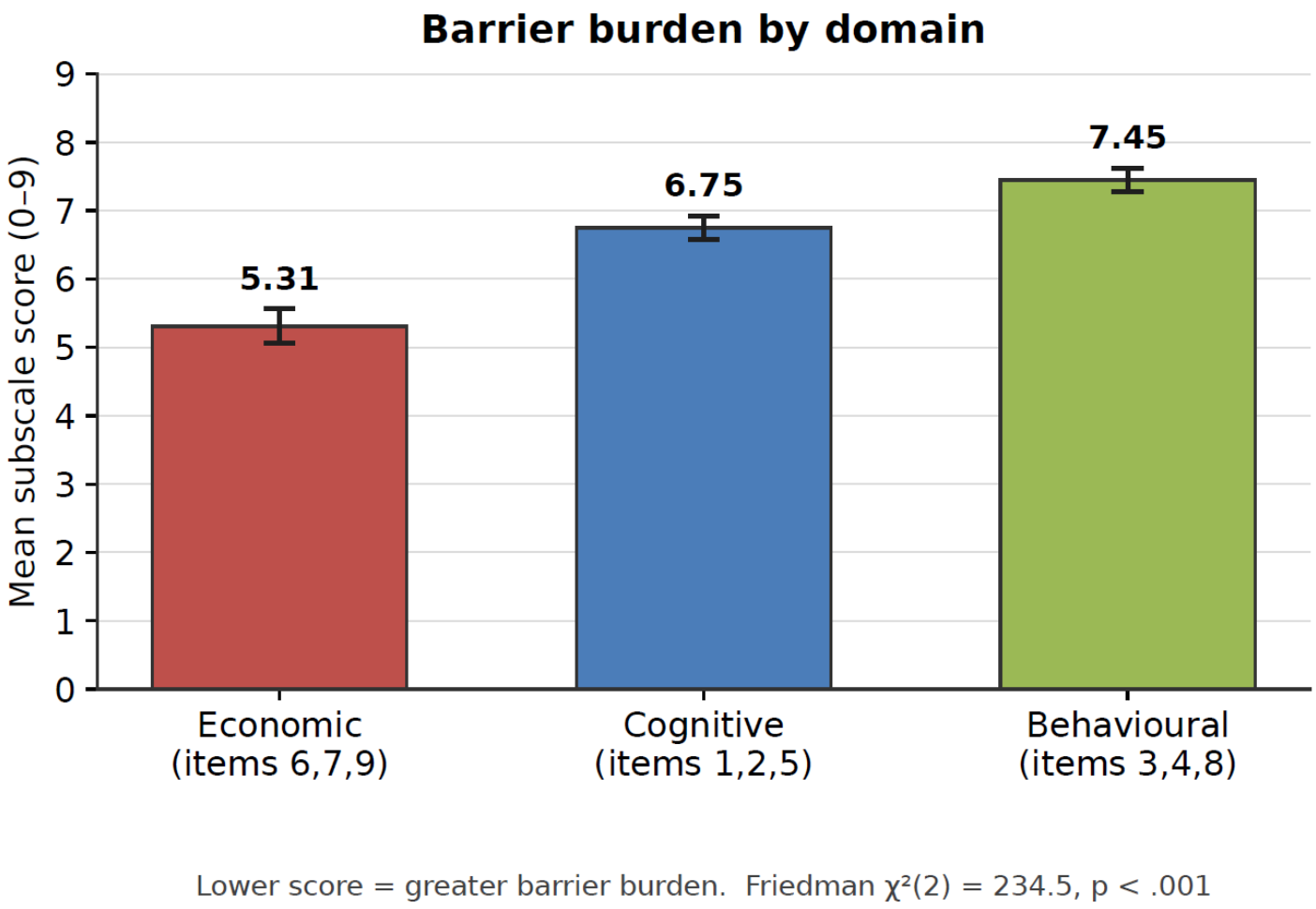


Figure 1

Barrier burden by domain (mean subscale score, 95% CI). Lower score = greater burden. Friedman $\chi^2(2) = 234.5$, $p < .001$.

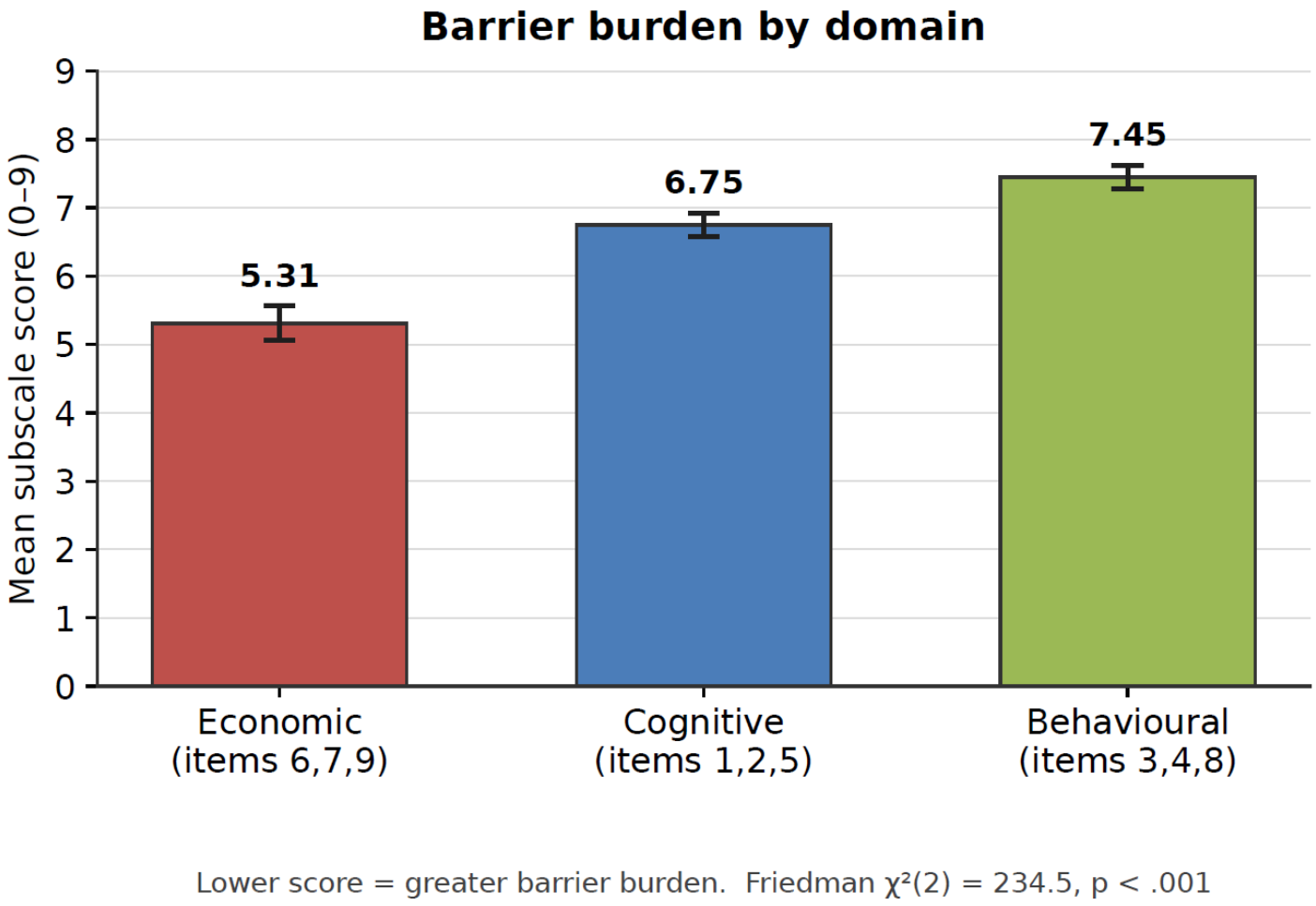


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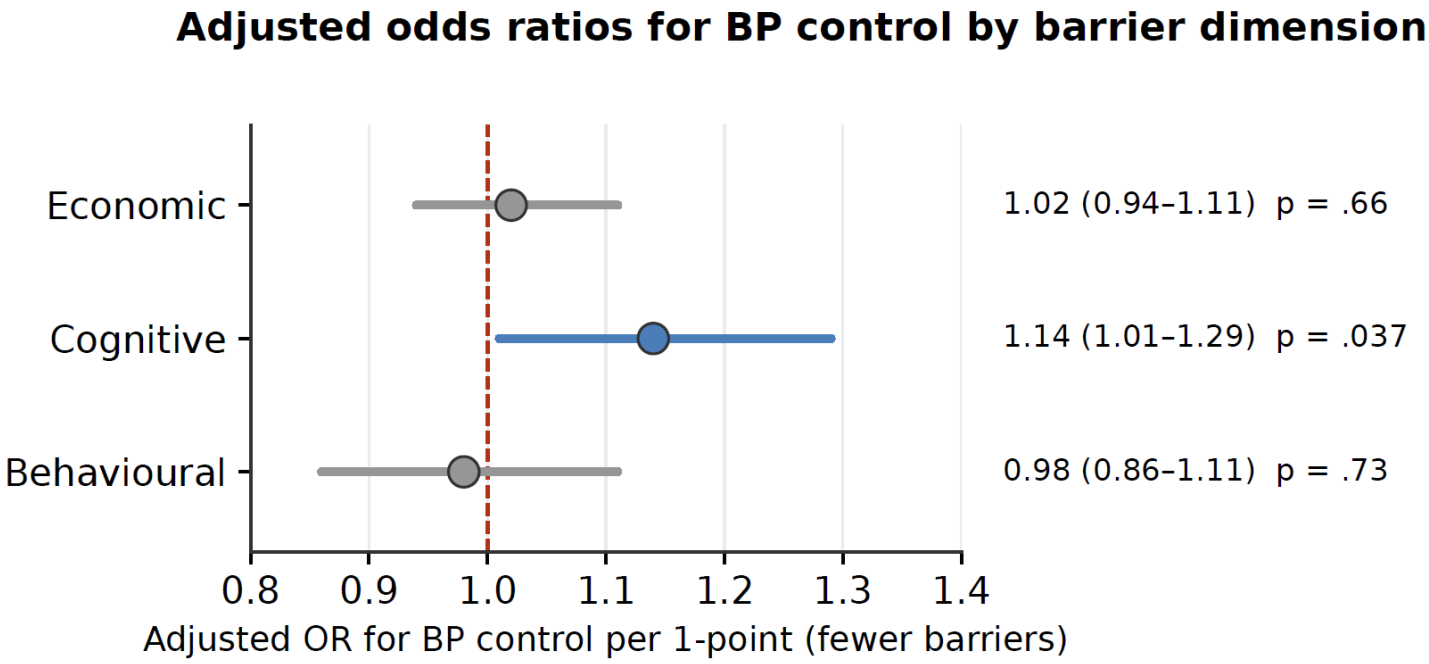


Figure 2

Adjusted odds ratios for BP control per 1-point of each barrier subscale (fewer barriers). Only the cognitive dimension is independently associated with control.

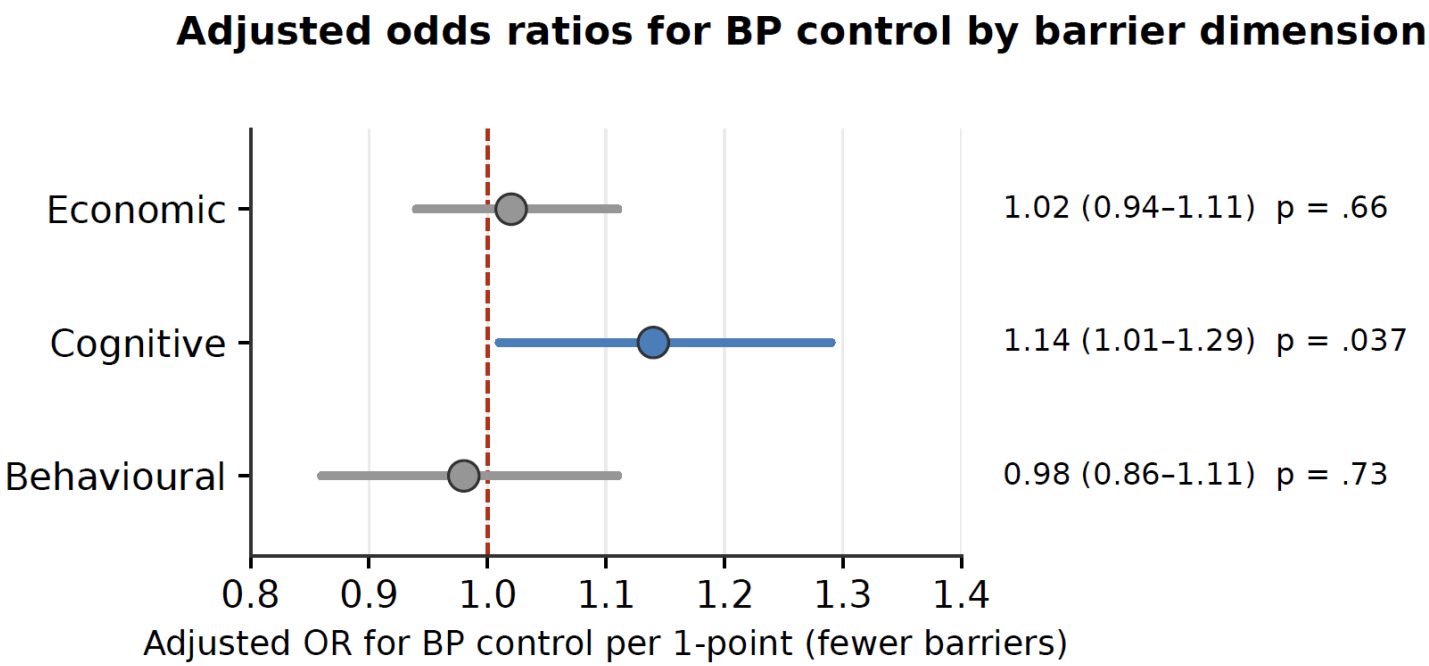


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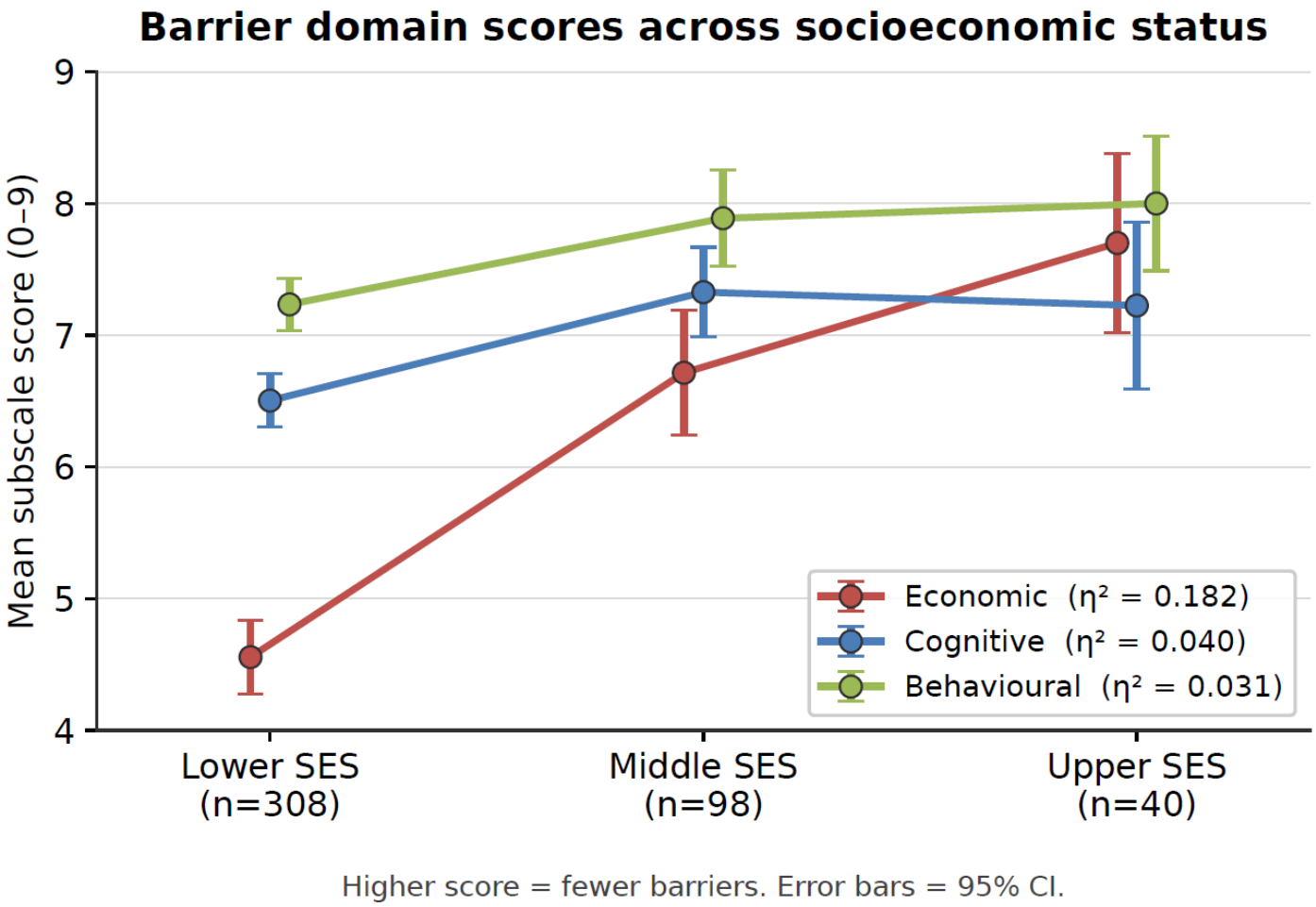


Figure 3

Barrier domain scores across socioeconomic status. Economic barriers rise steeply with SES (η² = .18); cognitive and behavioural gradients are shallow.

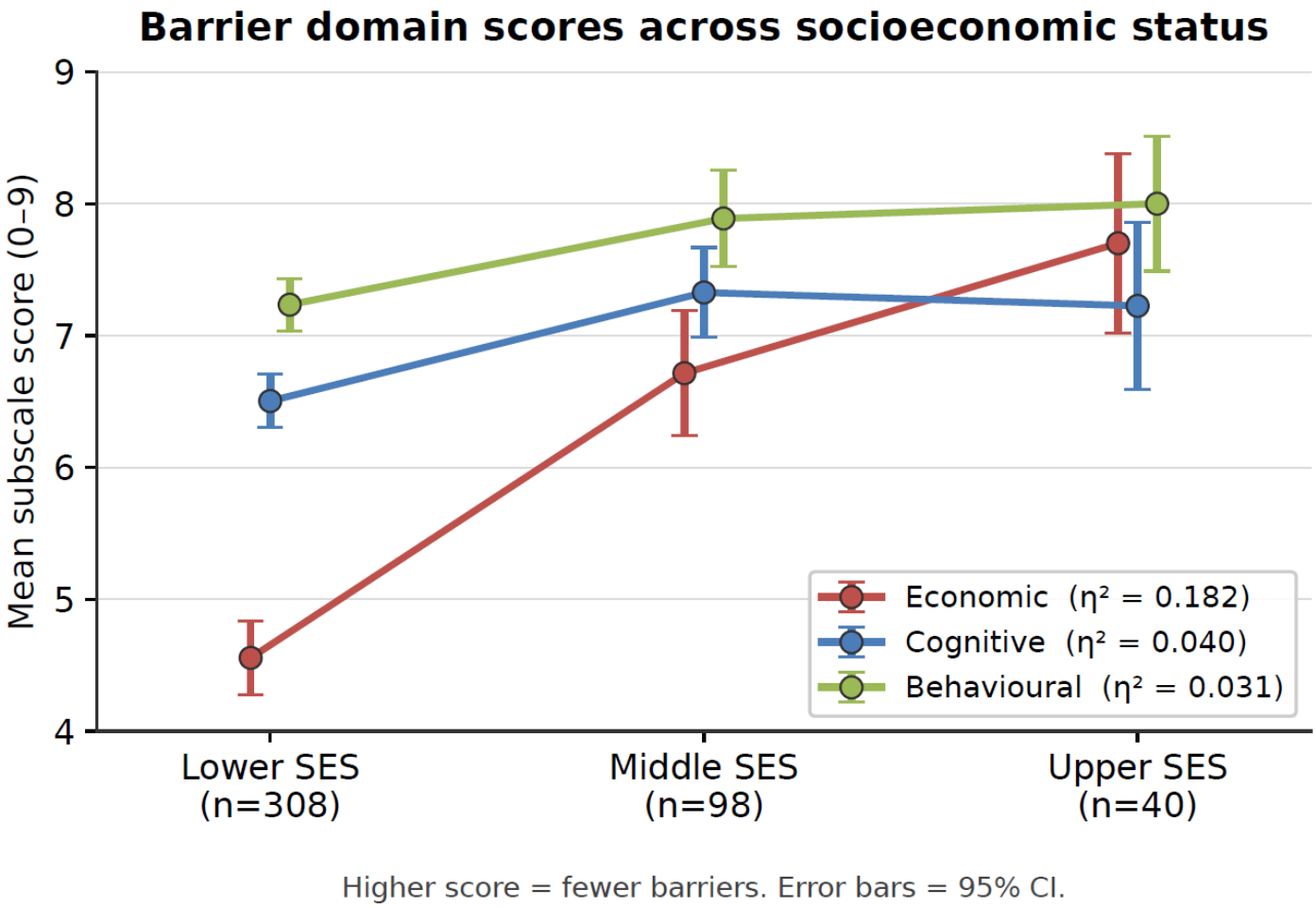


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Barrier domain scores across socioeconomic status. Economic barriers rise steeply with SES (η² = .18); cognitive and behavioural gradients are shallow.

Supplementary Files

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