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# Prevalence and Factors Associated with Borderline or Abnormal Ankle–Brachial Index Findings among Hospitalised Adults in Singapore: A Cross-Sectional Study

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## Abstract

# Background

Peripheral arterial disease (PAD) is frequently under-recognised because individuals may be asymptomatic or present with atypical symptoms. Although an ankle–brachial index (ABI) < 0.90 is considered abnormal and suggestive of PAD, borderline ABI values (0.91–0.99) may also identify individuals at increased risk of PAD and cardiovascular disease. Evidence on borderline ABI among general hospitalised adults in Singapore remains limited.

# Methods

A cross-sectional study using convenience sampling was conducted among adults aged ≥ 50 years without known PAD who were admitted to Internal Medicine wards at a tertiary hospital in Singapore between February 2024 and April 2025. Demographic and clinical characteristics and bilateral ABI measurements were collected. ABI was classified as abnormal (< 0.90), borderline (0.91–0.99), or normal (1.00–1.40). Characteristics were compared across ABI groups,and multivariable linear regression was used to identify factors associated with the lowest ABI per participant. A linear mixed-effects model accounted for bilateral ABI measurements.

# Results

Among 122 participants, 83 (68.0%) had normal ABI in both limbs, 29 (23.8%) had at least one borderline ABI without an abnormal ABI, and 10 (8.2%) had at least one abnormal ABI. Overall, 39 (32.0%) had at least one borderline or abnormal ABI finding. Routine lower-limb clinical findings were predominantly normal among affected limbs. In multivariable analysis, increasing age (B = − 0.002, p = 0.018) and higher BMI (B = − 0.005, p = 0.006) were independently associated with lower ABI values. Participants with diabetes had higher adjusted ABI values than those without diabetes (p = 0.027). These associations remained statistically significant in the bilateral mixed-effects model (age, p = 0.030; BMI, p = 0.002; diabetes mellitus, p = 0.033).

# Conclusion

Borderline or abnormal ABI findings were identified in approximately one-third of hospitalised adults aged ≥ 50 years without previously diagnosed PAD, despite predominantly normal bedside vascular findings. Identifying individuals with borderline ABI may provide an opportunity for earlier cardiovascular risk assessment and follow-up before progression to abnormal ABI or clinically recognised PAD. Larger multicentre studies are needed to confirm these findings and evaluate targeted vascular assessment strategies and their potential to improve clinical outcomes.

# BACKGROUND

Peripheral arterial disease (PAD) is a substantial and growing global public health concern. It is a manifestation of systemic atherosclerosis characterised by narrowing or occlusion of the arteries supplying the lower extremities, resulting in reduced arterial blood flow and impaired tissue perfusion (1, 2). PAD is clinically important because affected individuals have an increased risk of cardiovascular events, including myocardial infarction and stroke, as well as limb-related complications, amputation and premature mortality (3).

Globally, more than 200 million adults are estimated to be living with PAD, with the burden increasing with population ageing and the growing prevalence of cardiovascular risk factors (4-7). PAD also represents an important health concern in Asian populations. In Singapore, available epidemiological data suggest the burden varies considerably by the population studied. The Singapore cohort of the international Reduction of Atherothrombosis for Continued Health (REACH) Registry reported PAD among patients with established atherothrombotic disease or multiple cardiovascular risk factors (8). Other local studies have reported PAD among multi-ethnic community populations and selected high-risk groups, including individuals with diabetes mellitus, cardiovascular disease and stroke (9-12). However, these studies largely focused on selected or high-risk populations, and data on PAD and ABI findings among general hospitalised adults in Singapore remain limited.

An important challenge in detecting PAD is that many individuals are asymptomatic or present with atypical lower-limb symptoms rather than classic intermittent claudication (1, 2, 7). Consequently, PAD may go unrecognised, limiting opportunities for timely cardiovascular risk assessment and management. This is particularly relevant among older hospitalised adults, who often have multiple cardiovascular risk factors and comorbidities.

Given these diagnostic challenges, objective vascular assessment may help identify individuals with otherwise unrecognised disease. The ankle–brachial index (ABI) is a simple, non-invasive, and inexpensive physiological test used to assess lower-extremity PAD (3). According to the American College of Cardiology/American Heart Association guidelines, an ABI ≤0.90 is classified as abnormal, while values between 0.91 and 0.99 are classified as borderline (5, 13). Although a borderline ABI does not meet the conventional diagnostic threshold for PAD, it may still have clinical relevance. Previous studies have associated borderline ABI with progression to PAD, increased mortality, adverse cardiovascular outcomes and endothelial dysfunction (5, 14).

Among individuals with type 2 diabetes, borderline ABI has also been associated with microvascular and macrovascular complications (15). These findings suggest that borderline ABI may represent an intermediate vascular-risk state warranting closer cardiovascular risk assessment and follow-up, while remaining distinct from an abnormal ABI suggestive of PAD. Despite the potential clinical significance of borderline ABI, little is known about its prevalence among general hospitalised adults in Singapore. Existing local studies have predominantly focused on community populations or selected high-risk groups, including individuals with diabetes, cardiovascular disease and stroke (10-12, 16, 17). Therefore,

the burden of previously unrecognised borderline and abnormal ABI findings among older adults admitted to general medical wards remains unclear.

Establishing the prevalence of these findings is an important first step in determining whether selected hospitalised adults may benefit from further vascular assessment. Individuals admitted to general medical wards may have cardiovascular risk factors despite having no recognised PAD or typical lower-limb symptoms. Identifying borderline or abnormal ABI findings may allow earlier cardiovascular risk assessment and appropriate follow-up. Therefore, determining the prevalence of borderline and abnormal ABI findings and identifying associated factors is important, as this may provide preliminary evidence to identify groups that may benefit from targeted vascular assessment and inform future PAD screening strategies in Singapore.

***Screening for PAD***

Current international guidelines do not include a recommendation for universal PAD screening among asymptomatic adults at low risk but support ABI assessment in individuals considered at increased risk, including older adults and those with diabetes mellitus, smoking exposure, hypertension, dyslipidaemia or established cardiovascular disease (5). ABI is commonly used as a first-line non-invasive physiological assessment because it is inexpensive and reproducible (18).

**Despite the availability of ABI assessment, PAD remains under-recognised because many individuals may be asymptomatic or have atypical manifestations, and ABI assessment is not routinely performed in all clinical settings** (19, 20). In Singapore, evidence describing previously unrecognised borderline and abnormal ABI findings among general hospitalised adults is limited (21). Hospitalised adults may represent an important population for vascular risk identification because older age and multiple cardiovascular comorbidities are common in the inpatient setting.

Establishing the prevalence of borderline and abnormal ABI findings among hospitalised adults, and whether routine lower-limb assessment can identify these findings, is important. This information provides preliminary evidence to inform decisions about targeted screening or further assessment (22).

***Factors associated with PAD***

The development and progression of PAD are associated with several established cardiovascular risk factors. Increasing age is strongly associated with PAD prevalence, particularly after 50 years of age (4, 23, 24). Cigarette smoking is an important modifiable risk factor, while diabetes mellitus, hypertension, dyslipidaemia and chronic kidney disease are also associated with atherosclerotic disease and adverse cardiovascular and limb outcomes (25-27). (17, 28-30)

Other demographic and clinical characteristics, including ethnicity, BMI, renal impairment and previous cardiovascular disease, have also been associated with PAD in different populations (31, 32). However, much of this evidence comes from selected high-risk populations. Less is known about factors

associated with the distribution of ABI values, particularly borderline ABI, among broader hospitalised adult populations.

Although current international and local guidelines recommend targeted ABI assessment for individuals at increased risk of PAD, routine ABI screening has not been widely implemented in Singapore. Consequently, many individuals with asymptomatic or atypical disease may remain undiagnosed until advanced disease develops. Existing Singapore studies have primarily focused on selected high-risk populations, including patients with diabetes mellitus, cardiovascular disease, stroke, or specific ethnic groups, with limited data on the prevalence and clinical characteristics of borderline ABI. Furthermore, the demographic and clinical characteristics associated with borderline and abnormal ABI in a general hospitalised adult population remain poorly understood. Given Singapore's ageing population and the burden of cardiovascular comorbidities among hospitalised adults, describing the prevalence and distribution of borderline and abnormal ABI findings represents an important first step towards understanding whether targeted vascular assessment in this setting warrants further investigation.

# Methods

Aim

To (i) determine the prevalence of borderline and abnormal ABI findings among hospitalised adults aged ≥50 years without a known diagnosis of PAD, and (ii) explore demographic and clinical factors associated with ABI values in this population.

Study design and setting of the study

This was a cross-sectional study conducted in the Department of Internal Medicine wards of an acute tertiary hospital in Singapore. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (33). Eligible participants were recruited between February 2024 and April 2025.

Participants

Participants were eligible for inclusion if they met all of the following criteria: (i) aged 50 years or older; (ii) admitted under the discipline of Department of Internal Medicine (DIM); and (iii) able to provide written informed consent.

Participants were excluded if they met any of the following criteria: (i) terminal illness; (ii) cognitive impairment that precluded informed consent; (iii) a known diagnosis of peripheral arterial disease (PAD); (iv) chronic limb-threatening ischaemia (CLTI); (v) deep vein thrombosis; or (vi) bilateral upper- or lower-limb wounds that prevented placement of the blood pressure cuff for ankle–brachial index (ABI) measurement. Patients with bilateral upper- or lower-limb wounds were excluded because ABI measurement requires systolic blood pressure measurements from both brachial arteries and both ankles.

NKG and WMJ conducted initial screening from Monday to Friday. The hospital census was reviewed daily to identify new admissions to the Department of Internal Medicine (DIM). The research team then reviewed these patients' electronic medical records to determine eligibility. The research team approached eligible patients in the inpatient wards and invited them to participate. Written informed consent was obtained before enrolment. Following consent, study assessments and ABI measurements were completed during the same visit, with no further follow-up required. The entire process took approximately 30 minutes. Participants were allowed adequate rest during the assessment to minimise fatigue and rested supine for 5–10 minutes before ABI measurement.

*Sample size*

The sample size was estimated based on the hospital's general medical inpatient caseload of approximately 1,500 admissions per month. Using a population proportion formula with a 5% margin of error and a 95% confidence level, the minimum required sample size was estimated to be 227 participants. As the final recruited sample was smaller than the estimated target, analyses examining factors associated with ABI were considered exploratory.

*Measurement*

ABI was measured using a single handheld Doppler device to assess lower-limb pulses. Systolic blood pressures at both the ankle and brachial sites were measured using an 8 MHz Doppler probe (Dopplex D900, Huntleigh Technologies, Cardiff, UK). The ABI was calculated as the ratio of ankle systolic blood pressure to brachial systolic blood pressure. Measurements were obtained after participants had rested supine for 5–10 minutes. A single systolic blood pressure measurement was recorded from the right and left brachial arteries and the right and left ankles. The cuff was rapidly inflated to maximum pressure and then gradually deflated at two mmHg per second until the first audible Doppler signal was heard, which was recorded as the systolic pressure. Peripheral pulses were identified using the Doppler probe at the dorsalis pedis (DP) and posterior tibial (PT) arteries. The ABI was measured separately for the right and left legs while the participant was at rest. For each limb, the highest systolic pressure from either the DP or PT artery was divided by the highest systolic pressure measured from both brachial arteries to obtain the ABI value.

ABI values were classified according to standard categories as abnormal (<0.90), borderline (0.91–0.99), normal (1.00–1.40), or non-compressible (>1.40). An abnormal ABI (<0.90) was classified as abnormal and considered suggestive of PAD (5). Borderline ABI values (0.91–0.99) were not considered diagnostic of PAD but were included as an intermediate category that may warrant further vascular assessment.

*Data collection*

A structured data-collection form was used to standardise data capture and minimise omission of required variables. The form recorded demographic and clinical characteristics, including age, sex,

admitting diagnosis, body mass index (BMI), smoking status, relevant comorbidities, capillary refill, pedal pulses and lower-limb temperature bilaterally.

ABI measurements were performed by trained study team members using a Doppler device and blood pressure cuff. Bilateral brachial and ankle systolic pressures were measured using a standardised protocol. Before data collection, all study team members received hands-on training on the use of the Doppler device and ABI measurement procedure to minimise inter-operator variation. The equipment was calibrated prior to use. Formal inter-rater reliability testing was not conducted.

*Statistical analysis*

Statistical analyses were performed using IBM SPSS Statistics version 26. Continuous variables were summarised using means and standard deviations (SD) and categorical variables as frequencies and percentages. ABI was classified at the participant level as normal when both limbs had ABI values of 1.00–1.40, borderline when at least one limb had an ABI of 0.91–0.99 without an abnormal ABI, and abnormal when at least one limb had an ABI <0.90. The prevalence of borderline, abnormal, and combined borderline/abnormal ABI findings was calculated. Group differences were assessed using one-way ANOVA for continuous variables and Pearson's chi-square or exact tests, as appropriate.

Univariable linear regression examined factors associated with the lowest ABI value per participant. Variables for multivariable analysis were selected based on univariable findings and established clinical relevance to PAD, with the number of covariates limited by the sample size. Age, sex, BMI, diabetes mellitus, hypertension, hyperlipidaemia and past smoking were included in the multivariable model. A linear mixed-effects model using bilateral ABI measurements was additionally performed to account for within-participant correlation, with limb side included as a covariate. Results are reported as unstandardised coefficients (B), 95% confidence intervals (CI) and p-values; standardised coefficients (β) are also reported for the multivariable linear regression. All tests were two-sided, with $p<.05$ considered statistically significant.

*Ethics*

The study was conducted in accordance with the Declaration of Helsinki and approved by the SingHealth Centralised Institutional Review Board (2023/2166). Written informed consent was obtained from all participants before enrolment, and participants were informed of their right to withdraw at any time.

# Results

*Participant characteristics and ABI findings*

A total of 3,346 admission records were screened. Of these, 2,967 met the initial eligibility criteria and were assessed for recruitment. Subsequently, 122 participants were recruited (Figure 1). The mean age of participants was 68.09 years (SD 10.01), and the mean BMI was 24.78 kg/m² (SD 5.51). Most participants were male (n=69, 56.6%) and of Chinese ethnicity (n=90, 73.8%). Hyperlipidaemia (n=77,

63.1%) and hypertension (n=76, 62.3%) were the most common comorbidities (Table 1). Participant characteristics were generally comparable across the normal, borderline and abnormal ABI groups (Table 1).

*Prevalence of borderline and abnormal ABI*

Of the 122 participants, 83 (68.0%) had normal ABI values in both limbs, 29 (23.8%) were classified as having borderline ABI, and 10 (8.2%) were classified as having abnormal ABI. The prevalence of borderline ABI was therefore 23.8%, while the prevalence of abnormal ABI was 8.2%. Overall, 39 participants (32.0%) had either a borderline or abnormal ABI finding.

*Lower-limb characteristics among participants with borderline or abnormal ABI findings*

Among the 39 participants with at least one borderline or abnormal ABI finding, 25 (64.1%) had the finding in one limb, while 14 (35.9%) had findings in both limbs. Routine lower-limb clinical assessment findings were predominantly within normal limits among limbs with borderline or abnormal ABI. Capillary refill of 1–2 seconds was observed in 96.6% of right and 100.0% of left affected limbs. Dorsalis pedis and posterior tibial pulses were palpable in 100.0% of right and 100.0% of left affected limbs, while 93.1% of right and 100.0% of left affected limbs were warm to touch (Table 2).

*Univariable associations with lowest ABI*

In exploratory univariable linear regression analyses using the lowest unilateral ABI value per participant as the continuous dependent variable, increasing age was associated with lower ABI (B=−0.002, 95% CI −0.003 to 0.000, p=.049). Gender was also associated with ABI, with males having higher ABI values than females (B=0.036, 95% CI 0.002 to 0.070, p=.038). BMI showed an inverse association with ABI that did not reach statistical significance (B=−0.003, 95% CI −0.006 to 0.000, p=.057). No statistically significant univariable associations were observed for ethnicity, past or current smoking, ischaemic heart disease, diabetes mellitus, hypertension, hyperlipidaemia, renal disease, musculoskeletal disease, gastrointestinal/hepatological disease or respiratory disease (Table 3).

*Multivariable associations with lowest ABI*

In the multivariable linear regression model, age, BMI and diabetes mellitus were independently associated with lowest ABI. Increasing age was associated with lower ABI (B=−0.002, 95% CI −0.004 to 0.000, β=−0.244, p=.018), while increasing BMI was also associated with lower ABI (B=−0.005, 95% CI −0.008 to −0.001, β=−0.267, p=.006). Participants with diabetes had higher adjusted ABI values than those without diabetes (B = 0.043, 95% CI 0.005 to 0.081, p = 0.027). Gender, past smoking, hypertension and hyperlipidaemia were not independently associated with lowest ABI. The overall model was statistically significant, $F(7,114)=3.482$, $p=0.002$, explaining 17.6% of the variance in lowest ABI ($R^2=0.176$; adjusted $R^2=0.126$) (Table 4).

*Mixed-effects analysis of bilateral ABI*

A linear mixed-effects model was additionally performed using bilateral ABI measurements to account for the correlation between right and left limbs within participants. Age (B=−0.002, 95% CI −0.004 to 0.000, p=0.030) and BMI (B=−0.005, 95% CI −0.008 to −0.002, p=.002) remained significantly associated with lower ABI values. Participants with diabetes had higher adjusted ABI values than those without diabetes (B=0.039, 95% CI 0.003 to 0.076, p=0.033). Gender, hypertension, hyperlipidaemia and past smoking were not statistically significant. There was no significant difference in ABI between right and left limbs after adjustment (B=−0.007, 95% CI −0.029 to 0.015, p=0.535) (Table 5).

# Discussion

This study examined the prevalence of borderline and abnormal ABI findings and factors associated with ABI among hospitalised adults aged ≥50 years without PAD. This study found that 23.8% of hospitalised adults aged ≥50 years without previously diagnosed PAD had a borderline ABI, while 8.2% had an abnormal ABI. Overall, 32.0% had at least one borderline or abnormal ABI finding. Borderline ABI accounted for most of these findings. Previous Singapore studies have reported varying PAD prevalence depending on the population studied, with much of the available evidence coming from individuals with diabetes, cardiovascular disease, stroke or other high-risk groups (10, 12, 30). Direct comparisons should therefore be made cautiously because of differences in study populations and diagnostic approaches. The present findings do not represent PAD prevalence in the general Singapore population. Rather, they highlight a potentially important burden of previously unrecognised borderline and abnormal ABI findings among older general medical inpatients.

The relatively high prevalence of borderline ABI is particularly relevant because it does not meet the diagnostic threshold for PAD but has been associated with progression to PAD, cardiovascular events and mortality in previous studies (15, 34, 35). Identifying individuals with borderline ABI may therefore provide an opportunity for earlier cardiovascular risk assessment, preventive management and follow-up, rather than waiting until ABI becomes abnormal or PAD is clinically recognised. However, whether earlier identification and intervention can prevent disease progression or improve clinical outcomes requires prospective evaluation.

Another important finding was that routine lower-limb clinical assessments were predominantly normal among limbs with borderline or abnormal ABI. Almost all affected limbs had palpable dorsalis pedis and posterior tibial pulses, normal capillary refill and were warm to touch. PAD is frequently asymptomatic or associated with atypical rather than classical symptoms, contributing to under-recognition in clinical practice (1, 4, 20).

These findings demonstrate that apparently reassuring bedside findings can coexist with borderline or abnormal ABI values. Although this study was not designed to assess the diagnostic accuracy of physical examination, the findings suggest that routine clinical assessment alone may not identify all individuals with ABI abnormalities. This highlights the importance of considering a patient's broader cardiovascular risk profile alongside routine lower-limb assessment.

Increasing age and BMI were independently associated with lower ABI, and both associations remained significant when bilateral ABI measurements were considered. The association with increasing age is consistent with previous studies showing that PAD becomes more common with advancing age (4, 24, 25). Higher BMI was also associated with lower ABI in this study. However, BMI is an indirect measure of adiposity and does not distinguish between fat mass, muscle mass or fat distribution. This is particularly relevant among older adults, in whom changes in body composition may not be adequately reflected by BMI alone (36). Therefore, the observed association should be interpreted cautiously, and future studies incorporating measures of central adiposity and body composition are needed to clarify the relationship between BMI and ABI.

Diabetes mellitus was also independently associated with ABI in both adjusted analyses. However, participants with diabetes had slightly higher adjusted ABI values than those without diabetes, an unexpected finding given that diabetes is an established risk factor for PAD. Medial arterial calcification in individuals with diabetes may result in less compressible arteries and falsely elevated ABI values despite underlying arterial disease (5, 37). This may partly explain the observed association, although arterial calcification was not assessed in this study. The small sample size and inpatient case mix may also have contributed to this finding. Therefore, the association should not be interpreted as suggesting that diabetes is protective against PAD.

Smoking, hypertension and hyperlipidaemia were not independently associated with ABI in this study. Although smoking, hypertension and hyperlipidaemia were not independently associated with ABI, the small sample size may have limited the ability to detect statistically significant associations. Larger studies are needed to confirm the factors associated with ABI and determine which combinations of clinical characteristics may help identify individuals who would benefit from further vascular assessment.

*Implications to practice*

The findings highlight the need to increase awareness that borderline or abnormal ABI findings may be present in hospitalised adults despite predominantly normal routine lower-limb assessments. Identifying borderline ABI may provide an earlier opportunity for cardiovascular risk assessment, preventive management and appropriate follow-up. Particular attention may be warranted among older adults and individuals with higher BMI, while established cardiovascular risk factors, including diabetes, should remain important considerations in clinical assessment.

However, this study alone does not provide sufficient evidence to recommend routine ABI screening. Implementation may be challenging because ABI measurement requires appropriate equipment, staff training and time. Further research is needed to develop and validate practical risk-assessment approaches that identify patients who may benefit from targeted vascular assessment. Such approaches may help guide the use of available resources and inform future PAD screening strategies in hospitalised adults.

### Limitations

Several limitations should be considered when interpreting the findings. First, the planned sample size of 227 was not achieved, with 122 participants recruited because of operational constraints, patient refusal and the fixed study timeline. The smaller sample may have reduced statistical power and precision; therefore, analyses of factors associated with ABI should be considered exploratory. The single-centre, cross-sectional design limits generalisability and does not allow causal conclusions. Weekday-only recruitment and excluding patients unable to provide consent or undergo ABI measurement may also have introduced selection bias. In addition, comorbidities were obtained from electronic medical records, and potentially relevant factors such as disease duration and severity, medication use, physical activity and frailty were not collected, resulting in possible residual confounding.

Second, limitations related to vascular assessment should be acknowledged. ABI measurement was the primary physiological vascular assessment. In individuals with diabetes or chronic kidney disease, arterial calcification may increase ankle pressures and affect ABI interpretation (5, 37). Complementary assessments, such as toe–brachial index, toe pressure measurement, Doppler waveform analysis or vascular imaging, were not routinely performed. We also could not independently confirm the presence and severity of underlying arterial disease. Finally, although trained assessors performed ABI measurements using a standardised protocol, we did not assess formal inter-rater reliability. ABI values were also based on a single measurement at each anatomical site rather than repeated measurements. Measurement variability related to cuff placement, Doppler probe position or operator technique therefore cannot be excluded.

### Future research

Larger multicentre studies are needed to establish the prevalence and clinical significance of borderline and abnormal ABI findings and to validate factors that may identify individuals who would benefit from further vascular assessment. Prospective studies should also examine whether individuals with borderline ABI progress to abnormal ABI, clinically recognised PAD or cardiovascular and limb-related events. Future studies should incorporate complementary vascular assessments, particularly in individuals with diabetes or chronic kidney disease, in whom ABI interpretation may be affected by arterial calcification (5, 37). Further research should develop and validate practical risk-assessment approaches that combine demographic characteristics, cardiovascular risk factors, symptoms and clinical findings to identify individuals who may benefit from targeted vascular assessment. The cost-effectiveness of targeted screening strategies should also be evaluated, including healthcare costs, earlier detection and referral, prevention of disease progression, and outcomes such as quality-adjusted life years (QALYs).

Finally, future studies could evaluate nurse-led vascular or claudication services for individuals identified as being at increased risk or with established PAD. Such studies should examine their effectiveness in supporting cardiovascular risk-factor management, exercise and lifestyle interventions, patient

education, timely referral and longer-term clinical outcomes, as well as their feasibility and cost-effectiveness.

## Conclusion

Borderline or abnormal ABI findings were identified in almost one-third of hospitalised adults aged ≥50 years without previously diagnosed PAD, with borderline ABI accounting for the majority of these findings. Routine lower-limb clinical assessments were predominantly normal, suggesting that these findings may remain unrecognised when bedside examination appears reassuring. Increasing age and BMI were independently associated with lower ABI, while the association between diabetes and higher adjusted ABI requires cautious interpretation.

Importantly, identifying individuals with borderline ABI may provide an opportunity for earlier cardiovascular risk assessment, preventive management and follow-up before progression to abnormal ABI or clinically recognised PAD. Larger multicentre and prospective studies are needed to confirm these findings and determine whether targeted vascular assessment can reduce disease progression, improve clinical outcomes and provide a cost-effective approach to PAD prevention.

## Declarations

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**Clinical trial number:** Not Applicable

**Data availability:** The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Authorship Confirmation / Contribution Statement (CRediT Format)**

**NG:** Conceptualization; Methodology; Data curation; Formal analysis; Writing – original draft; Project management, Writing – review & editing

**FA, DDR:** Review analysis, Conceptualization; Writing – review & editing.

**MJW, WTG,HRC, YL, OQMG:** Data management, Writing – review & editing.

**ASY, KCES, TTC:** Conceptualization; Supervision; Writing – review & editing.

All authors confirm that they have made substantial contributions to the work as outlined above, have approved the final version of the manuscript, and agree to be accountable for all aspects of the work.

**Declaration of generative AI and AI-assisted technologies in the manuscript preparation process:** During the preparation of this work, the author(s) used Grammarly to improve writing clarity and correct any grammar or spelling errors in the manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

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# Tables

Tables 1 to 5 are available in the Supplementary Files section.

# Figures

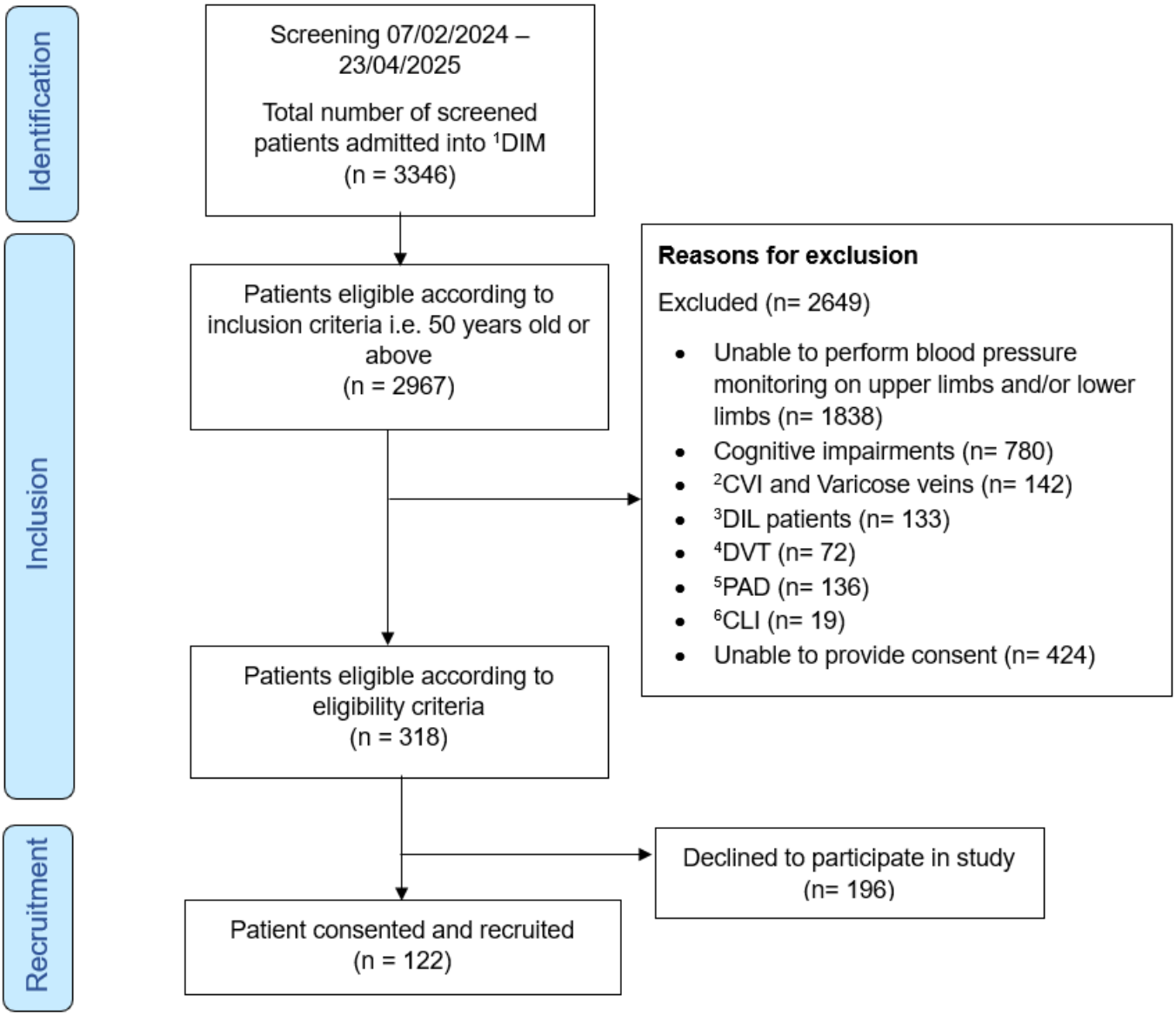



**Figure 1**

# Supplementary Files

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- Table120.9.26.docx
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