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Analysis of the Combined Screening Value of Glycated Hemoglobin and Fasting Blood Glucose in Community-Based Geriatric Health Checkups

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Abstract

To evaluate the value of glycated hemoglobin (HbA1c) and fasting plasma glucose (FPG) for diabetes screening in community-dwelling elderly population, both individually and collectively, and thereby providing evidence for optimizing early diabetes screening strategies in community health checkups, 200 elderly residents aged ≥65 years who underwent annual health examinations at the Southeast Community Health Service Center of Deyang City, Sichuan Province, China from January to December 2025 were enrolled. All participants underwent HbA1c and FPG testing. Using the oral glucose tolerance test (OGTT-2hPG ≥ 11.1 mmol/L) as the golden standard for diabetes diagnosis, we calculated and compared the sensitivity, specificity, Youden index, and area under the receiver operating characteristic curve (AUC) for FPG, HbA1c, and their combined screening. Results showed that among the 200 subjects, the diabetes detection rate via OGTT was 16.5% (33 cases), and HbA1c screening (cutoff 6.2%) demonstrated a sensitivity of 81.8%, significantly higher than FPG screening (cutoff 6.1 mmol/L) at 66.7%, but its specificity (89.8%) was slightly lower than FPG (94.0%). Among them, the series combination yielded the highest specificity (98.2%), while the parallel combination achieved the highest sensitivity (93.9%). The AUC was 0.927, indicating significantly superior screening performance compared to single tests. The Youden index suggested the parallel combination as the optimal strategy. In conclusion, in community-based geriatric health examinations, glycated hemoglobin could serve as an effective diabetes screening indicator. The parallel combination of glycated hemoglobin and fasting plasma glucose might significantly enhance screening sensitivity, reduce missed diagnoses, and would be suitable for large-scale screening in community-dwelling elderly population.

Keywords: glycated hemoglobin, fasting plasma glucose, diabetes mellitus, screening, elderly community health examination

1. Introduction

Diabetes is a metabolic disorder characterized by hyperglycemia resulting from impaired carbohydrate metabolism (American Diabetes Association Professional Practice Committee et al., 2024), and has become a major global public health challenge. Its prevalence increases significantly with age, placing a heavy burden on healthcare systems, while early diagnosis is crucial for preventing complications and improving prognosis (Gourlay et al., 2023). Among the elderly population, diabetes and its complications represent major risk factors for disability, cardiovascular events, and mortality (Editorial Board of Clinical Guidelines for the Prevention and Treatment of Type 2 Diabetes in the Elderly in China et al., 2022). Furthermore, diabetes can lead to brain and neurological disorders, making the monitoring of prediabetes and control of blood glucose levels critically important (Shin et al., 2023). Given that diabetes in the elderly often presents insidiously with atypical symptoms, early screening and diagnosis are critical for initiating timely interventions and improving outcomes.

Currently, fasting plasma glucose (FPG) and oral glucose tolerance test (OGTT) serve as traditional diagnostic standards for diabetes. However, OGTT is cumbersome, time-consuming, and susceptible to multiple confounding factors, limiting its feasibility for large-scale community screening (World Health Organization, n.d.). Although FPG is simple, it has limitations in community settings: it requires subjects to fast for 8-12 hours, and results are significantly affected by recent diet, stress, and other factors. Besides, intra-day and inter-day variability may lead to missed diagnoses (Kohsaka et al., 2012), and its sensitivity is insufficient for detecting prediabetes and some newly diagnosed diabetes cases (Sacks, 2011). Glycated hemoglobin (HbA1c) assesses average blood glucose levels over the preceding 2–3 months and reflects glycemic control. It exhibits low variability, does not require fasting, and offers convenient testing, providing relatively accurate information for clinical management (Gourlay et al., 2023). In 2010, the American Diabetes Association formally incorporated HbA1c $\geq$ 6.5% into its diagnostic criteria for diabetes (American Diabetes Association, 2010), and its role in screening and diagnosis has gained increasing recognition (ElSayed et al., 2023). However, HbA1c testing carries relatively high costs and may be influenced by conditions such as anemia, hemoglobinopathies, and renal failure (Editorial Board of Clinical Guidelines for the Prevention and Treatment of Type 2 Diabetes in the Elderly in China et al., 2022).

Domestic and international studies have explored the application value of HbA1c in screening, and relevant research indicates that its combined monitoring demonstrates good predictive value for the onset of type 2 diabetes (Zhao Wei et al., 2022). However, among the specific population of community-dwelling elderly individuals, research on optimized strategies for combined HbA1c and FPG screening and direct comparisons with the golden standard remains insufficient (Bergenstal et al., 2022). The screening efficacy and value of combining HbA1c with FPG require further clarification through localized research data (Bao et al., 2010). Given the uncertainty, this study aims to systematically evaluate the screening efficacy of HbA1c and FPG, both individually and in various combinations, among community-dwelling elderly undergoing health examinations, using OGTT as the golden standard. This evaluation seeks to provide evidence-based guidance for developing cost-effective community diabetes screening pathways for current clinical application and future research.

2. Research Methods

2.1 General Information

This study employed a cross-sectional design. A total of 200 eligible elderly residents who underwent annual health examinations at the Southeast Community Health Service Center between January and December 2025 and met the following criteria were consecutively enrolled. Inclusion criteria: ① Age ≥65 years; ② No prior history of diabetes; ③ Informed consent and voluntary participation in the study. Exclusion criteria: ① Previously diagnosed diabetes under treatment; ② Severe hepatic/renal insufficiency, end-stage disease, acute infection, or stress state; ③ Recent (within 3 months) blood transfusion history or hemoglobin disorders (e.g., anemia) affecting HbA1c measurement; ④ Incomplete data.

2.2 Testing Methods

All subjects completed the following tests on the day of physical examination:

Fasting Plasma Glucose (FPG): Venous blood collected after at least 8 hours of overnight fasting was tested using the glucose oxidase method on a biochemical analyzer. The diagnostic cutoff adopted the WHO standard: FPG ≥7.0 mmol/L.

Glycated Hemoglobin (HbA1c): EDTA-anticoagulated venous blood was collected and analyzed using high-performance liquid chromatography (HPLC, Bio-Rad D-10™ system). The diagnostic cutoff followed the ADA standard (ElSayed et al., 2023): HbA1c ≥6.5%.

Oral Glucose Tolerance Test (OGTT-2hPG): All subjects (regardless of FPG or HbA1c results) underwent a standard 75g OGTT, with 2-hour post-glucose glucose (2hPG) measured. An OGTT-2hPG ≥11.1 mmol/L served as the golden standard for diabetes diagnosis (World Health Organization, n.d.).

All testing procedures followed standard operating protocols. Daily quality control of instruments ensured results remained within acceptable ranges.

2.3 Screening Strategy and Diagnostic Cutoffs

Single-marker screening:

FPG positive cutoff: ≥6.1 mmol/L (based on ADA prediabetes cutoff, balancing sensitivity) (American Diabetes Association, 2010).

HbA1c positive cutoff: ≥6.2% (slightly below diagnostic criteria based on pilot studies and literature to enhance screening sensitivity) (Zhang et al., 2010).

Combined Screening:

Parallel Combination: FPG ≥ 6.1 mmol/L or HbA1c ≥ 6.2% is considered screening positive.

Serial Combination: FPG ≥ 6.1 mmol/L and HbA1c ≥ 6.2% is required for screening positivity.

2.4 Statistical Methods

Data analysis was performed using SPSS 26.0 software. For continuous variables meeting normal distribution, results were expressed as mean ± standard deviation ($\bar{x} \pm s$), with intergroup comparisons conducted using t-tests; non-normally distributed variables were presented as medians and analyzed using the Mann-Whitney U test. Categorical variables were reported as counts (%) and evaluated using chi-square (χ^2) tests. Sensitivity, specificity, positive predictive value, negative predictive value, positive likelihood ratio, negative likelihood ratio, and Youden's index were calculated for each screening strategy relative to the golden standard. Receiver operating characteristic (ROC) curves were plotted, and the area under the curve (AUC) along with its 95% confidence interval was calculated. The DeLong test was used to compare AUC differences. $P < 0.05$ was considered statistically significant.

3. Results

3.1 Baseline Characteristics of Study Participants

The 200 elderly subjects had a mean age of 72.4 ± 5.8 years, with 98 males (49.0%). Participants were divided into a diabetes group (n = 33) and a non-diabetes group (n = 167) based on OGTT results. No significant differences existed between groups in age or gender distribution ($P > 0.05$). The diabetic group exhibited significantly higher FPG, HbA1c levels, and BMI compared to the non-diabetic group ($P<0.01$). See Table 1.

Table 1. Comparison of Basic Characteristics Between Diabetic and Non-Diabetic Groups

Characteristic	Total (n=200)	Diabetes Group (n=33)	Non-Diabetes Group (n=167)	Statistical Value	*P-value*
Age (years)	72.4±5.8	73.1±6.2	72.2±5.7	*t*=0.875	0.383
Male, n (%)	98 (49.0)	18 (54.5)	80 (47.9)	χ^2=0.491	0.483
BMI (kg/m²)	24.1±3.2	25.8±3.5	23.7±2.9	t=3.785	<0.001
FPG (mmol/L)	5.8±1.0	7.2±1.3	5.5±0.7	t=11.237	<0.001
HbA1c (%)	5.9±0.7	6.8±0.6	5.7±0.5	t=12.346	<0.001

3.2 Comparison of Screening Strategy Efficacy

Using OGTT as the golden standard, FPG screening (cutoff ≥6.1 mmol/L) detected 32 positive cases, including 22 true positives; HbA1c screening (cutoff ≥6.2%) detected 43 positive cases, including 27 true positives. Parallel combined screening (positive for either HbA1c or FPG) detected 59 positive cases, including 31 true positives. Serial combined screening (positive for both HbA1c and FPG) detected 21 positive cases, including 18 true positives. Specific efficacy metrics are shown in Table 2 and Figure 1.

Table 2. Comparison of Screening Efficacy for Diabetes Among Community-Dwelling Elderly Residents Using Different Screening Strategies (n=200)

Screening Strategy	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	Youden Index
FPG (≥6.1)	66.7 (22/33)	94.0 (157/167)	68.8(22/32)	93.5(157/168)	0.607
HbA1c (≥6.2%)	81.8 (27/33)	89.8 (150/167)	62.8(27/43)	95.5(150/157)	0.716
Parallel combined screening	93.9 (31/33)	83.8 (140/167)	52.5(31/59)	98.6(140/142)	0.777
Series combined screening	54.5(18/33)	98.2 (164/167)	85.7(18/21)	92.0(164/178)	0.527

Note: PPV: Positive Predictive Value; NPV: Negative Predictive Value. Numbers in parentheses indicate sample size.

As shown in Table 2, HbA1c screening alone demonstrated significantly higher sensitivity than FPG screening, though with slightly lower specificity. The parallel combined test achieved the highest sensitivity at 93.9% while maintaining a high negative predictive value (98.6%), but specificity decreased to 83.8%. The series combined test achieved the highest specificity at 98.2% and a positive predictive value of 85.7%, but its sensitivity was lower than that of single FPG screening.

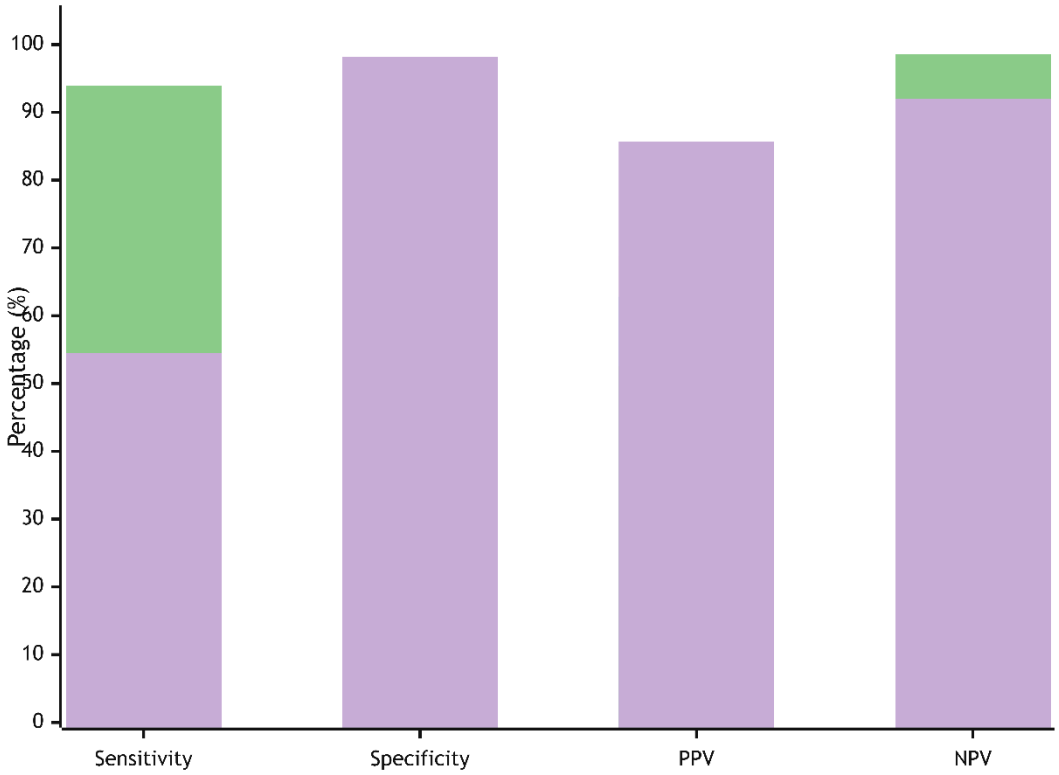

Figure 1. Comparison of Screening Effectiveness for Community-Based Elderly Diabetes Using Different Screening Strategies

Note: FPG (fasting plasma glucose); HbA1c (glycated hemoglobin); parallel (parallel combined testing); serial (serial combined testing). The parallel combined strategy achieved the highest sensitivity (93.9%), while the serial combined strategy achieved the highest specificity (98.2%).

3.3 ROC Curve Analysis

ROC curve analysis was performed for FPG and HbA1c as continuous variables (Figure 2). The AUC for HbA1c was 0.887 (95% CI: 0.832–0.942), while the AUC for FPG was 0.848 (95% CI: 0.783–0.913). The AUC for the combined indicator using a parallel combination strategy (i.e., selecting the optimal cutoff values for both) was 0.911 (95% CI: 0.865–0.957). The DeLong test indicated that the AUC for combined screening was significantly higher than that for FPG screening alone ($P < 0.05$), but the difference compared with HbA1c screening alone was not statistically significant ($P > 0.05$), as shown in Figure 2.

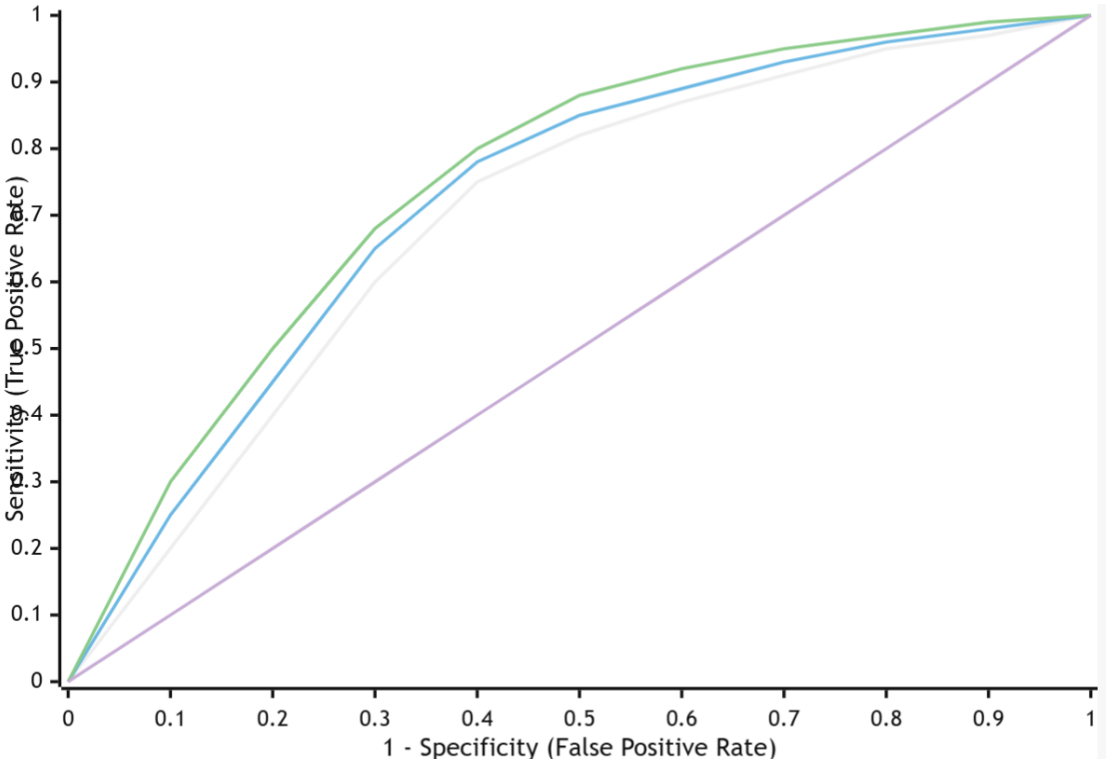

Figure 2. ROC Curves for FPG, HbA1c, and Parallel Combined Screening for Diabetes

Note: Blue line (HbA1c, AUC=0.902); Gray line (FPG, AUC=0.872); Green line (parallel combination, AUC=0.927); Purple line: Reference line (random classifier performance, AUC=0.5). The combined screening curve lies closest to the upper-left corner with the highest AUC, indicating optimal overall discriminative capability.

4. Discussion

This study systematically compared the value of FPG, HbA1c, and their combined strategy in diabetes screening within a real-world community-based elderly health examination setting. Results demonstrated that HbA1c screening alone exhibited significantly higher sensitivity than FPG (81.8% vs. 66.7%), consistent with findings from multiple international studies in both general and elderly populations (Lu et al., 2010; Sacks, 2011). HbA1c which reflects long-term blood glucose levels, is unaffected by short-term dietary intake, exercise, or stress, and does not require fasting. These characteristics make it more suitable as a community-based initial screening tool in terms of compliance and convenience. Ensuring the quality of HbA1c measurements will help prevent misdiagnosis of diabetes and avoid overtreatment or undertreatment of high-risk individuals (Heinemann et al., 2018). However, glycated hemoglobin (HbA1c) has limitations in describing both short-term and long-term glycemic control (Vigersky & McMahon, 2019). Relevant studies suggest adopting a multi-marker combined strategy in high-risk populations, and further exploring the predictive value of HbA1c in long-term follow-up is essential (Zhao Wei et al., 2022). Related studies also provide references for model construction and validation in diabetes screening (Bosun-Arije et al., 2020).

The core finding of this study is that the parallel combined screening strategy (where a positive result in either FPG or HbA1c indicates the need for further confirmation) increases sensitivity to 93.9% while maintaining a high negative predictive value (98.6%). This indicates that the strategy minimizes missed diagnoses, making it highly suitable for community health examinations where "case detection" is the primary screening objective. In contrast, the series combined strategy, despite its extremely high specificity, exhibits insufficient sensitivity (54.5%), resulting in nearly half of diabetic patients being missed and thus unsuitable for screening. ROC curve analysis further confirmed the superiority of parallel combination screening. Although HbA1c's AUC was slightly higher than FPG's, neither achieved the screening efficacy of parallel combination when used alone. Thus, their combined diagnostic capability proved optimal. This finding provides clear guidance for community practice: when resources permit, prioritizing "FPG + HbA1c" parallel combination initial screening can significantly enhance screening efficiency.

5. Limitations & Conclusion

Restrained by objective conditions, this study has certain limitations. First, the sample size was relatively small, and as a single-center study, the generalizability of its conclusions requires further validation through multicenter research. Second, it failed to incorporate additional potential confounding factors (such as renal function) for stratified analysis. Furthermore, HbA1c testing may be influenced by factors like ethnicity and anemia, necessitating careful consideration of the target population during implementation.

In community-based health examinations for elderly residents, glycated hemoglobin serves as a stable, convenient, and effective indicator for diabetes screening. The parallel testing strategy combining fasting plasma glucose with glycated hemoglobin significantly enhances screening sensitivity and effectively reduces missed diagnoses, making it an optimal approach for achieving efficient early detection of diabetes in community-dwelling elderly populations. It is recommended that community healthcare institutions incorporate HbA1c testing into health examination packages and establish a combined screening pathway with FPG to build a robust early defense line within the comprehensive diabetes prevention and control network.

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Competing interests

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Obtained.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.

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