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Changes in Community Pharmacists' Self-Assessed Explanatory Ability and Preventive Awareness Following an Integrated Atrial Fibrillation Screening and Community Education Programme: A Longitudinal Study

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Abstract

This uncontrolled longitudinal study examined changes in community pharmacists' self-assessed explanatory ability and preventive awareness during an integrated e-learning, atrial fibrillation (AF) screening and community education programme. Twenty-seven pharmacists completed five five-point items at baseline (T0), after e-learning (T1) and after practical activities (T2). Friedman tests and Wilcoxon signed-rank tests were supplemented by exact conditional sign-permutation analyses, with Bonferroni correction within each item. Resident health check-up recommendations were assessed using paired counts and a pharmacy-clustered sensitivity analysis. Prevention awareness increased from T0 to T1 (exact $p = 0.001953$), whereas self-assessed stroke and AF explanation increased from T1 to T2 ($p = 0.004395$ and 0.004883). Exact comparisons supported T0–T2 increases in self-assessed ability to explain stroke and AF and awareness of prevention; the increase in perceived activity value did not meet the corrected threshold ($p = 0.0195$). Among 223 repeat participants, recommendations increased from 7.6% to 22.4%, a difference of 14.8 percentage points (pharmacy-clustered 95% CI −4.7 to 34.3). Of 44 free-text responses, 26 were obtained at T0, 10 at T1 and eight at T2. Participation was associated with changes in three self-assessed outcomes. Resident recommendations varied substantially between pharmacies. Although causal effects and clinical benefit remain unestablished, the findings support further evaluation of integrated learning and practice to strengthen pharmacists' contribution to cardiovascular prevention.

Keywords: atrial fibrillation; community pharmacy services; continuing professional development; electrocardiography; pharmacists; primary prevention

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1. Introduction

Cardiovascular disease remains an important public health concern in Japan. In the 2025 final vital statistics, heart disease excluding hypertensive disease and cerebrovascular disease were the second and fourth leading causes of death, accounting for 13.9% and 6.3% of deaths, respectively [1]. Japan's Second Basic Plan for the Promotion of Cardiovascular

Disease Countermeasures emphasises prevention, public understanding and collaboration across healthcare professions, including community pharmacies [2].

Community pharmacies offer opportunities for AF awareness-raising and opportunistic electrocardiographic (ECG) screening [3–6]. Japanese pharmacy-based studies have also described screening initiatives [7,8]. However, identifying a possible rhythm abnormality is distinct from confirming AF or preventing clinical events. The STROKESTOP trial found a small benefit of invitation to screening on a composite clinical endpoint in older adults [9], whereas the LOOP trial increased AF detection and anticoagulation initiation without a statistically significant reduction in stroke or systemic arterial embolism [10]. Differences in population, screening strategy and follow-up limit direct extrapolation to pharmacy-based education programmes.

Education may influence pharmacists' knowledge, confidence and awareness, but these outcomes should be distinguished from observed practice. Earlier studies examined educational interventions in hypertension care [11,12]. More recently, a Japanese smoking cessation education study reported changes in knowledge and self-efficacy [13], while a randomised study of computer-based education for point-of-care testing found knowledge gains without a corresponding significant increase in testing activity [14]. These findings support measuring educational perceptions and implementation separately.

Continuing education reviews describe diverse formats and a preference for learning relevant to practice, while highlighting limited evidence linking education to patient outcomes [15,16]. A five-state pilot showed that structured support can help pharmacists adopt a reflective continuing professional development approach [17]. These findings motivate examining both perceived learning and implementation, without assuming that an educational programme necessarily improves patient outcomes.

Self-efficacy theory concerns beliefs about one's capability to perform a task [18]. A tobacco-cessation education study examined pharmacists' confidence, skills and practice change [19], and a Japanese survey related counselling self-efficacy to experience and workplace factors [20]. This literature provides a conceptual context for self-assessed explanatory ability. The present programme-specific items, however, were not designed or validated as a self-efficacy scale.

Building on Japanese pharmacy-based AF screening research [7,8], this study adds assessment of pharmacists' perceptions at three stages of an integrated education and practice programme. The present study aimed to describe longitudinal changes in community pharmacists' self-assessed ability to explain stroke and AF and their preventive awareness during a programme combining structured e-learning, pharmacy-based ECG screening and resident health education. Recorded resident recommendations and screening findings were examined as exploratory implementation outcomes.

2. Materials and Methods

2.1. Study Design and Setting

This was a single-group, uncontrolled, longitudinal before-and-after study evaluating changes in pharmacists' self-assessed explanatory ability and perceptions of prevention at three time points. The study was conducted at member pharmacies of the Minami Ward Pharmacists Association in Fukuoka City, Fukuoka Prefecture, Japan. The overall pharmacist education programme was implemented from 10 February to 31 December 2025. Electrocardiographic screening for community residents was conducted in two phases: the first phase (first measurement) from 1 April to 30 June 2025 and the second phase (second measurement) from 1 October to 31 December 2025.

2.2. Pharmacist Recruitment

On 10 February 2025, a formal invitation to participate was distributed to all 123 member pharmacies of the Minami Ward Pharmacists Association in Fukuoka City. Pharmacies were eligible to participate if they met the following criteria: (1) at least one pharmacist attended the study information session held on 21 March 2025 or viewed its on-demand recording; (2) the prescribed e-learning programme provided by the Smart Healthcare Association was completed and "Ken-Spo" (Health and Sports Pharmacy) certification was obtained; and (3) a handheld home electrocardiography device equipped with blood pressure measurement and electrocardiogram (ECG) recording functions (HCR-7800T; OMRON Healthcare Co., Ltd., Muko, Kyoto, Japan) was deployed.

All pharmacists working at participating pharmacies who had completed the e-learning programme were eligible for inclusion. Pharmacists received study information and provided informed consent before completing the baseline questionnaire (T0). Written consent was documented between 21 March and 1 April 2025, before resident-facing activities began. Pharmacists who completed all three questionnaire assessments were included in the final analysis.

The sample size was determined by the number of eligible pharmacists who participated in the programme during the study period. All 123 member pharmacies were invited to participate, and 27 pharmacies met the eligibility criteria, with one pharmacist participating from each pharmacy. No formal a priori sample size calculation was performed.

2.3. Programme and Resident Procedures

(1) Structured e-learning: Pharmacists completed a mandatory 3.5-h e-learning programme developed by the Smart Healthcare Association. The programme covered the basic pathophysiology of atrial fibrillation (AF) and related cardiovascular diseases, the public health significance of cardiovascular disease prevention, the national policy framework (the Basic Act on Measures against Cardiovascular Diseases), operation of home electrocardiography devices, criteria for recommending medical consultation, interprofessional information sharing using tracing reports, and the clinical importance of regular health check-ups.

(2) Orientation and information session: An information session was held on 21 March 2025 to review the study objectives, ethical considerations, workflow, and pharmacists' roles.

(3) Resident recruitment and screening: Pharmacists invited pharmacy visitors to participate using a standardised information leaflet. Eligible participants were community residents aged 40 years or older who were not regularly attending an internal medicine clinic.

(4) Pre-measurement survey and measurement instructions: Pharmacists administered pre-measurement questionnaire ① (Section S2.1 of Supplementary File S2) and explained how to record an ECG using standardised illustrated instructions provided by OMRON. Residents performed the measurements themselves under pharmacist supervision.

(5) Health education and leaflet distribution: After measurement, pharmacists provided structured verbal explanations using a disease-awareness leaflet focusing on the symptoms and risks of stroke and AF (Section S2.2 of Supplementary File S2). They also distributed a health check-up awareness leaflet recommending annual health check-ups (Section S2.3 of Supplementary File S2).

The baseline resident criterion concerned regular attendance at an internal medicine clinic; it did not establish that every participant lacked a usual physician. The resident questionnaire separately asked about the presence of a usual physician. Residents who began regular attendance after the initial screening were not automatically excluded from repeat screening. One resident known to have started regular cardiology attendance did not return for the second screening.

One participant with a history of treated AF was eligible because he was not receiving internal medicine care at enrolment. A prior AF history alone was not treated as a diagnosis newly established by this screening.

(6) Post-measurement survey and actions: Post-measurement actions were recorded as none, health check-up recommendation, medical consultation recommendation, tracing report submission, unaddressed referral letter, or other. Annual preventive health check-ups and medical evaluation of a possible ECG abnormality were treated as different action categories. The original flowchart (Figure 1) describes consultation based on the participant's request, with the usual physician as the first choice and a local internist or cardiologist as the second choice. An unaddressed referral letter could be provided when a destination was not determined. The source questionnaire allowed one action choice per encounter; this does not establish that only one action actually occurred. Figure 1 reproduces the flowchart used during the study without alteration. It describes participant education, measurement and consultation procedures; it does not specify a mandatory one-to-one rule linking every device output to a particular action. Recorded device classifications and actions are reported in Section S2.6 of Supplementary File S2, and the available records for the seven residents with possible AF at the first measurement are summarised in Section S2.11 of Supplementary File S2.

ECG classifications were generated automatically by the device, rather than diagnosed by pharmacists. Before implementation, the device and reporting procedures were explained to the local medical association and association of internal medicine physicians to obtain their understanding of the programme. Physicians did not supervise the pharmacy measurements. Unclassified or analysis-failed recordings were repeated; when the same output persisted, it was entered unchanged in the questionnaire. ECG waveforms were saved as PDFs on the smartphone used for measurement and sent to a printer. Printed records were handed to residents, and records for medical institutions were transmitted by fax or handed over. The post-measurement action field allowed only one selection per encounter.

One possible-AF recording in each round was coded as a health check-up recommendation. No reason for choosing this category was recorded. The original codes were retained, and these recommendations were not reclassified as medical referrals or interpreted as completed diagnostic evaluation. No uniform referral deadline was specified.

(7) Second-phase screening: From October to December 2025, the procedures described in steps 3–6, from resident recruitment through the post-measurement survey and recommendations for medical consultation, were repeated. Post-measurement questionnaire ③ (Section S2.1 of Supplementary File S2) was administered at the end.

Information on subsequent resident consultations and reported outcomes was collected and recorded only to the extent documented in questionnaire free-text fields and other available study records. Ascertainment of confirmed clinical diagnoses was outside the scope of this study; these records were not treated as physician-adjudicated diagnoses.

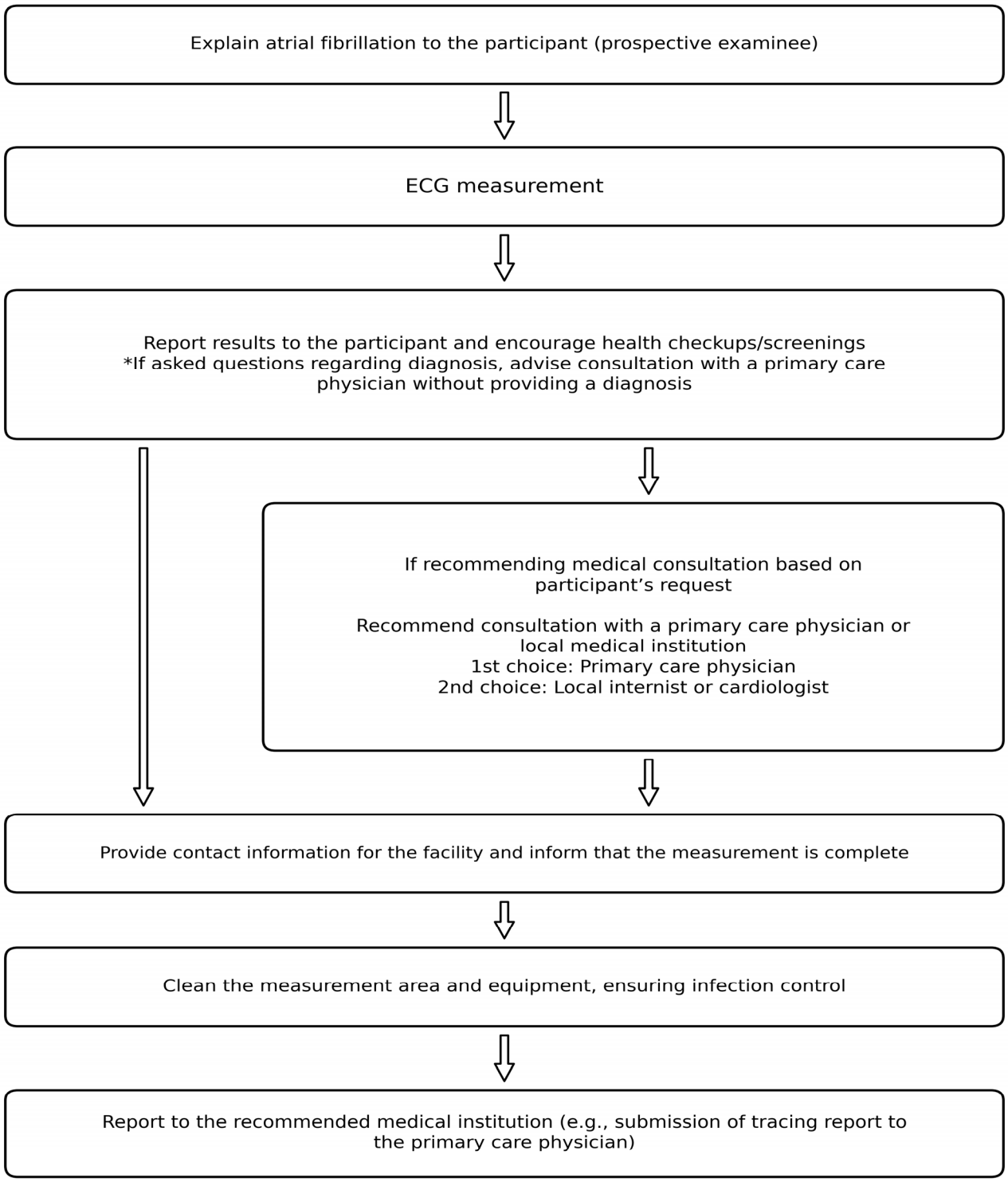


Figure 1. Flowchart for recommending medical consultation. * If participants asked about a diagnosis, pharmacists advised them to consult their primary care physician without making a diagnosis.

2.4. Pharmacist Outcomes and Assessment Timing

Pharmacists completed the questionnaire using Google Forms when expressing their intention to participate (T0), after completing e-learning and before resident screening (T1), and after completing programme activities (T2). T0, T1 and T2 denote the first, second and third assessments, respectively. Chihiro Nakamura administered and collected the questionnaires and was the only person with access to responses linked to pharmacists'

names. The Smart HealthCare Association, which provided the e-learning, did not have access to identifiable questionnaire responses.

Five single items assessed (Q1) self-assessed ability to explain stroke, (Q2) self-assessed ability to explain AF, (Q3) awareness of the importance of cardiovascular prevention before disease onset, (Q4) awareness of the importance of encouraging health check-ups, and (Q5) the perceived value of AF awareness and early-detection activities as a pharmacy role. Each item was scored 1–5, with higher values indicating more favourable self-assessment. No knowledge test, observed consultation assessment or independently rated competence measure was collected. These items were analysed separately and were not treated as a validated composite scale. Section S2.4 of Supplementary File S2 gives the Japanese items and response options alongside their English translations.

The questionnaire was developed by Chihiro Nakamura and Masao Ohmitsu with advice from the Smart HealthCare Association. Mitsuhiro Okazaki advised that questionnaires be administered before and after e-learning and that awareness of the importance of recommending health check-ups be included as an outcome. This developmental advice should not be interpreted as formal validation of the instrument. No pilot survey was conducted. They were used as separate self-assessment items, not as a validated composite instrument. For Q1 and Q2, the original Japanese response labels for levels 2 and 4 are semantically close: level 2 states that the respondent cannot explain confidently, whereas level 4 states that the respondent can explain but lacks confidence. Their separation may have been interpreted inconsistently. The original labels and numeric coding were retained; no retrospective rewording or rescoring was performed.

2.5. Free-Text Analysis

At each of the three surveys, an optional free-text field asked pharmacists to explain why they considered ECG measurement in pharmacies useful or challenging (Section S2.4 of Supplementary File S2). There was a maximum of 81 opportunities to respond (27 pharmacists × three surveys), and 44 free-text responses were obtained.

Responses were analysed using qualitative content analysis. Each individual free-text response was treated as the unit of analysis and assigned, according to its primary meaning, to one of five mutually exclusive categories: (1) early detection and prevention; (2) recommendations for medical consultation and collaboration with healthcare providers; (3) health awareness and education; (4) the role and value of pharmacies; and (5) other (operational burden, limitations regarding eligible participants, and neutral opinions). Detailed operational definitions and coding rules are presented in Section S2.5 of Supplementary File S2.

Two researchers independently classified all free-text responses using these coding criteria. Inter-coder agreement before consensus was assessed using unweighted Cohen's κ (Section S2.5 of Supplementary File S2). Disagreements were resolved through discussion, and the consensus classifications were used for the final descriptive analysis.

Response counts and categories were summarised by assessment time as well as overall. The response identifier does not identify a pharmacist across surveys; no within-person qualitative trajectory was inferred. Quotations and summaries were translated from Japanese.

2.6. Statistical Analysis

Scores were summarised using means (SDs), medians and interquartile ranges where relevant, and the frequency of each response category. Friedman tests used the tie-corrected statistic with the chi-square approximation (2 degrees of freedom). The originally reported pairwise Wilcoxon calculations were reproduced using the normal approximation, exclud-

ing zero differences, assigning average ranks to tied absolute differences and applying no continuity correction.

In response to peer review, exact conditional sign-permutation tests were added for all 15 pairwise comparisons. For each comparison, zero differences were excluded, average ranks were assigned to tied absolute differences, and the signs of the remaining differences were enumerated conditional on their absolute ranks. Two-sided probabilities included outcomes at least as extreme as the observed signed-rank sum. A dynamic-programming calculation of the rank-sum distribution avoided simulation error. The significance threshold was 0.05/3 (approximately 0.0167) for the three comparisons within each item; multiplicity across the five items was not controlled. Original asymptotic and exact results are both reported, and the revised interpretation follows the exact results. Mean-change 95% confidence intervals use the t distribution and are descriptive, unadjusted intervals rather than multiplicity-adjusted evidence of significance.

Reparticipants and non-reparticipants were compared descriptively on baseline age, sex, all six device ECG categories, initial health check-up recommendation and prior check-up attendance. Exploratory Welch t and Fisher exact tests were used for age and binary characteristics, respectively; the possible-AF test compares possible AF with all other device categories. No omnibus six-category test was used because of sparse cells. These unadjusted comparisons do not establish equivalence or rule out selection bias. Missing prior check-up history was excluded only from analyses of that variable.

For 223 residents screened twice, a paired 2 × 2 table and an exact McNemar test summarised changes in recorded check-up recommendations. A post hoc sensitivity analysis retained each resident's paired difference D = recommendation at round 2 minus recommendation at round 1 and estimated its mean with an intercept-only model. A pharmacy-clustered sandwich variance with the $G/(G-1)$ correction was calculated across the G = 20 pharmacies contributing paired observations, and confidence intervals and *p*-values used a t distribution with 19 degrees of freedom. This estimates the resident-weighted mean change and allows dependence among residents within a pharmacy. The original paired normal-approximation interval is also reported for comparison. Pharmacy-specific paired counts and screening volumes are provided; cluster-adjusted inference remains approximate with only 20 contributing pharmacies.

The original subgroup analyses involved 20 unadjusted tests (five items × four pharmacist attributes). Given the small and sometimes singleton subgroups, the revised manuscript replaces those hypothesis tests with descriptive mean changes by subgroup. These summaries are hypothesis-generating and cannot establish equal effects. The original analyses used IBM SPSS Statistics 29.0; the revision calculations used Python 3.12.14, NumPy 2.3.5 and SciPy 1.17.0. The added analyses and their timing are explicitly identified as post hoc.

All 27 pharmacists had complete five-item scores at three time points. All 332 resident records had age, sex, initial ECG category and initial action data; the 223 paired records had both action codes and post-baseline check-up attendance. Prior check-up history was missing for one resident in each participation group. No imputation was performed.

2.7. Ethics

The study was approved by the Ethics Committee of Daiichi University of Pharmacy (approval number R06-007; approved on 10 January 2025). Pharmacist informed consent preceded T0 questionnaire completion; written consent was documented before resident-facing activities. Residents provided written informed consent. Survey information stated that participation was voluntary, withdrawal was permitted and refusal would not result in disadvantage.

The ethical approval (R06-007) covered the resident component, including ECG measurement, questionnaires, research use of the data and linkage between the two measurement rounds. Residents received a written information sheet and provided written informed consent to participate. The information sheet described repeated measurement and questionnaires for the same residents, voluntary participation, confidentiality and use of results in academic presentations and publications without identifying individuals. The consent form included explanation and consent dates and signatures.

3. Results

3.1. Pharmacist Participation and Characteristics

Of 123 invited pharmacies, 28 expressed interest (22.8%) and 27 met the eligibility criteria (22.0%). One pharmacy did not meet the eligibility criteria because the pharmacist who had intended to participate was transferred before the study information session. One pharmacist per pharmacy completed e-learning, yielding 27 participants; all completed all three surveys. Seventeen were men (63.0%), 16 were managing pharmacists (59.3%), and 23 had completed a four-year pharmacy degree (85.2%). Ten predominant prescribing specialties were represented, including ophthalmology for two participants (7.4%). The specialty counts totalled 27 (Table 1).

Table 1. Characteristics of participating pharmacists. Categories A and B are membership categories of the Fukuoka City Pharmaceutical Association. Category A comprises managing pharmacists and other pharmacists wishing to contribute to the Association in this category; Category B comprises pharmacists who are not Category A members. These categories are distinct from employment roles. The four-year graduates in this study completed the former pharmacist-training curriculum; the six-year curriculum was introduced in 2006.

Characteristic	n (%)
Sex	
Male	17 (63.0)
Female	10 (37.0)
Association membership	
Category A	18 (66.7)
Category B	9 (33.3)
Pharmacist role	
Managing pharmacist	16 (59.3)
Other pharmacist	11 (40.7)
Experience in Years	
0 to <5	1 (3.7)
5 to <10	2 (7.4)
10 to <20	6 (22.2)
20 to <30	14 (51.9)
≥30	4 (14.8)
Pharmacy education	
Four-year programme	23 (85.2)
Six-year programme	4 (14.8)
Predominant prescribing specialty	
Internal medicine	11 (40.7)
Cardiology	2 (7.4)

Table 1. *Cont.*

Characteristic	n (%)
Neurosurgery	1 (3.7)
Paediatrics	3 (11.1)
Otorhinolaryngology	1 (3.7)
Orthopaedics	4 (14.8)
Dermatology	1 (3.7)
Dermatology/urology	1 (3.7)
Pain medicine	1 (3.7)
Ophthalmology	2 (7.4)

3.2. Changes in Pharmacist Scores

All 27 pharmacists completed the three assessments. At baseline, five pharmacists (18.5%) selected the highest response category for explaining stroke and five (18.5%) for explaining AF. Seven (25.9%) selected the highest category for pharmacy activity value. Both explanatory items had a T2 mean (SD) of 4.26 (0.66) and a T0–T2 mean change (SD) of 0.96 (1.26); these matching summary values were verified against the individual records.

All five Friedman tests indicated differences across the three assessments at the unadjusted 0.05 level (Table 2A). Exact pairwise comparisons used a within-item Bonferroni threshold of 0.05/3 (approximately 0.0167; Table 2B). From T0 to T1, awareness of the importance of cardiovascular prevention increased significantly, from 3.78 to 4.70 ($p = 0.001953$); none of the other four items met the corrected threshold. From T1 to T2, self-assessed ability to explain stroke increased from 3.74 to 4.26 ($p = 0.004395$), and ability to explain AF increased from 3.78 to 4.26 ($p = 0.004883$); the other three items did not show statistically significant changes. From T0 to T2, significant increases were observed in three items: ability to explain stroke (3.30 to 4.26; $p = 0.000702$), ability to explain AF (3.30 to 4.26; $p = 0.000690$), and prevention awareness (3.78 to 4.78; $p = 0.000427$). Awareness of the importance of encouraging health check-ups increased from 4.56 to 4.78 without statistical significance ($p = 0.314941$). Perceived value of pharmacy activities increased from 4.11 to 4.48, but did not meet the corrected threshold in the exact analysis ($p = 0.019531$), although it had done so in the original asymptotic analysis ($p = 0.012$). Full exact and asymptotic results and response distributions are provided in Section S2.8 of Supplementary File S2. Figure 2 shows the mean scores for all five items at the three assessment time points.

Table 2. A. Pharmacist scores and overall tests. B. Exact pairwise *p*-values and descriptive T0–T2 mean changes.

A					
Item	**T0 Mean (SD)**	**T1 Mean (SD)**	**T2 Mean (SD)**	**Friedman χ^2 (df = 2)**	***p***
Explaining stroke	3.30 (1.20)	3.74 (0.81)	4.26 (0.66)	14.156	0.000843
Explaining AF	3.30 (1.27)	3.78 (0.70)	4.26 (0.66)	13.324	0.001279
Importance of prevention	3.78 (1.34)	4.70 (0.54)	4.78 (0.58)	16.694	0.000237
Importance of check-up advice	4.56 (0.64)	4.85 (0.46)	4.78 (0.58)	7.189	0.027472
Value of pharmacy activities	4.11 (0.64)	4.52 (0.58)	4.48 (0.75)	8.379	0.015152
B					
Item	**T0–T1 *p***	**T1–T2 *p***	**T0–T2 *p***	**Mean Change (SD)**	**95% CI**
Explaining stroke	0.030182	0.004395	0.000702	0.96 (1.26)	0.47 to 1.46
Explaining AF	0.021484	0.004883	0.000690	0.96 (1.26)	0.47 to 1.46

Table 2. *Cont.*

Importance of prevention	0.001953	0.625000	0.000427	1.00 (1.27)	0.50 to 1.50
Importance of check-up advice	0.117188	0.500000	0.314941	0.22 (0.93)	−0.15 to 0.59
Value of pharmacy activities	0.030106	1.000000	0.019531	0.37 (0.69)	0.10 to 0.64

N = 27. Exact *p*-values are unadjusted; compare each with 0.05/3 within its item. No across-item correction was applied. Confidence intervals are descriptive and are not Bonferroni-adjusted. Mean-change intervals and signed-rank tests answer different questions. Section S2.8 of Supplementary File S2 includes zero-difference counts, W statistics, asymptotic *p*-values and exact Bonferroni-adjusted *p*-values.

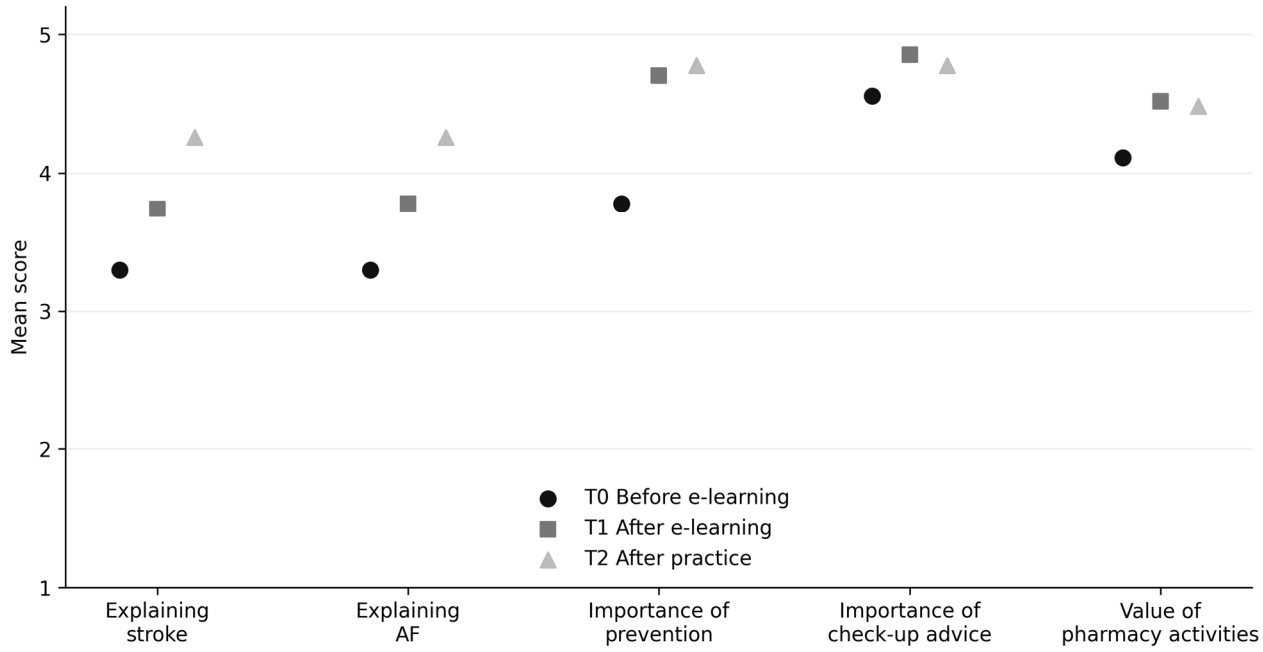


Figure 2. Mean scores at three time points. All items range from 1 to 5. N = 27 at each assessment. Table 2 provides SDs and tests Section S2.8 of Supplementary File S2; provides response distributions.

3.3. Exploratory Subgroup Descriptions

Exploratory subgroup summaries describe T0–T2 mean changes in all five items according to years of practice, pharmacy degree programme (four-year or six-year), predominant prescribing specialty and pharmacist role (Section S2.7 of Supplementary File S2). These summaries provide context for interpreting the overall changes across the participating pharmacists' professional backgrounds. Because several categories contained only one pharmacist, the revised analysis uses descriptive estimates rather than between-group hypothesis tests; it does not identify statistically supported subgroup differences or establish equivalent changes across groups.

3.4. Resident Participation and Baseline Comparison

Of 332 initial participants, 223 (67.2%) returned and 109 (32.8%) did not. The supplied records represented 26 pharmacy codes at round 1 and 20 at round 2 within the 27-pharmacy programme. The pharmacist at pharmacy 21 participated in training and approached residents, but the pharmacy reported no resident participants. This is a confirmed zero in the submitted resident dataset, rather than a missing pharmacy identifier. Across the 27 designated pharmacy codes, initial volume ranged from 0 to 35 residents (median 9; IQR 4.5–19.5). Among the 20 pharmacies with repeat participants, paired volume ranged from 1 to 27 (median 8; IQR 4.75–17.25). Section S2.9 of Supplementary File S2 gives all pharmacy-level counts.

Reparticipants and non-reparticipants had mean ages of 56.17 (SD 12.43) and 56.56 (SD 12.63) years, respectively; 73.1% and 66.1% were female. Possible AF at the initial screening occurred in 4/223 (1.8%) and 3/109 (2.8%). Initial check-up recommendations were recorded for 17/223 (7.6%) and 15/109 (13.8%). The observed differences and their exploratory *p*-values are reported in Table 3; lack of statistical significance does not exclude selective return. Reasons for non-return were not systematically ascertained for any of the 109 residents.

Table 3. Initial characteristics by repeat participation.

Characteristic	Repeat n = 223	No Repeat n = 109	Exploratory *p*
Age, years, mean (SD)	56.17 (12.43)	56.56 (12.63)	0.794
Age, median (IQR)	53 (46.5–63)	53 (47–64)	—
Female	163 (73.1)	72 (66.1)	0.200
Male	60 (26.9)	37 (33.9)	—
Normal sinus rhythm	212 (95.1)	101 (92.7)	—
Bradycardia	1 (0.4)	1 (0.9)	—
Tachycardia	2 (0.9)	1 (0.9)	—
Possible AF	4 (1.8)	3 (2.8)	0.688
Unclassified	1 (0.4)	2 (1.8)	—
Analysis failed	3 (1.3)	1 (0.9)	—
Initial health check-up recommendation	17 (7.6)	15 (13.8)	0.111
Prior health check-up attendance	150/222 (67.6)	63/108 (58.3)	0.111

Values are n (%) unless stated otherwise. Age *p*: Welch *t* test. Binary *p*-values: two-sided Fisher exact tests. The possible-AF *p*-value compares possible AF with all other categories, not the entire six-category distribution. Prior check-up history has one missing value in each group. Tests are unadjusted for multiplicity and pharmacy clustering and are descriptive aids only.

3.5. Recorded Check-Up Recommendations and Attendance

Among the 223 residents assessed in both rounds, recorded health check-up recommendations increased from 17 (7.6%) to 50 (22.4%), an absolute increase of 14.8 percentage points. Forty-four residents received a recommendation only at round 2, 11 only at round 1, six at both and 162 at neither (Table 4). The unclustered paired analysis supported an increase (95% CI 8.6 to 21.0 percentage points; exact McNemar $p = 0.00000870$). The point estimate remained at 14.8 percentage points after accounting for pharmacy clustering, but uncertainty was greater (95% CI −4.7 to 34.3; $p = 0.129$), and statistical significance was not retained in this sensitivity analysis.

Table 4. Paired recorded health check-up recommendations.

Round 1	Round 2 No	Round 2 Yes	Total
No	162	44	206
Yes	11	6	17
Total	173	50	223

N = 223, 20 contributing pharmacies. Exact McNemar $p = 0.00000870$. The pharmacy-clustered analysis of resident differences used a small-sample correction and t(19) inference: difference 14.8 percentage points, 95% CI −4.7 to 34.3, $p = 0.129$. Recommendations are not attendance or clinical outcomes.

Among the 20 pharmacies contributing paired records, recommendation rates increased in six, decreased in four and were unchanged in ten. Two pharmacies accounted for 36 of the 44 residents receiving a recommendation only at round 2; their net increases were 13 and 19, compared with 33 overall. This concentration limits interpretation as a programme-wide change.

At the second assessment, 98/223 residents (43.9%) reported a health check-up since their first ECG measurement. Of 150 with a previous-year check-up, 81 (54.0%) reported a subsequent check-up; among 72 without a previous-year check-up, 17 (23.6%) reported a subsequent check-up. One resident with missing prior history reported no subsequent check-up. These are self-reported attendance data; they do not establish that the programme caused attendance, whether a new recommendation was indicated at each encounter, or whether attendance preceded a particular recommendation.

3.6. Free-Text Responses

Forty-four eligible responses were analysed: 26/27 at T0, 10/27 at T1 and 8/27 at T2. Initial agreement was 41/44 (93.2%; Cohen's $\kappa = 0.906$), and three disagreements were resolved by discussion. Overall categories were early detection and prevention (19; 43.2%), referral and collaboration (7; 15.9%), health awareness and education (4; 9.1%), pharmacy role and value (8; 18.2%), and other (6; 13.6%). Figure 3 and Section S2.10 of Supplementary File S2 show the timing. Because most responses were obtained before education and response rates differed over time, pooled themes do not demonstrate change in perceptions or behaviour.

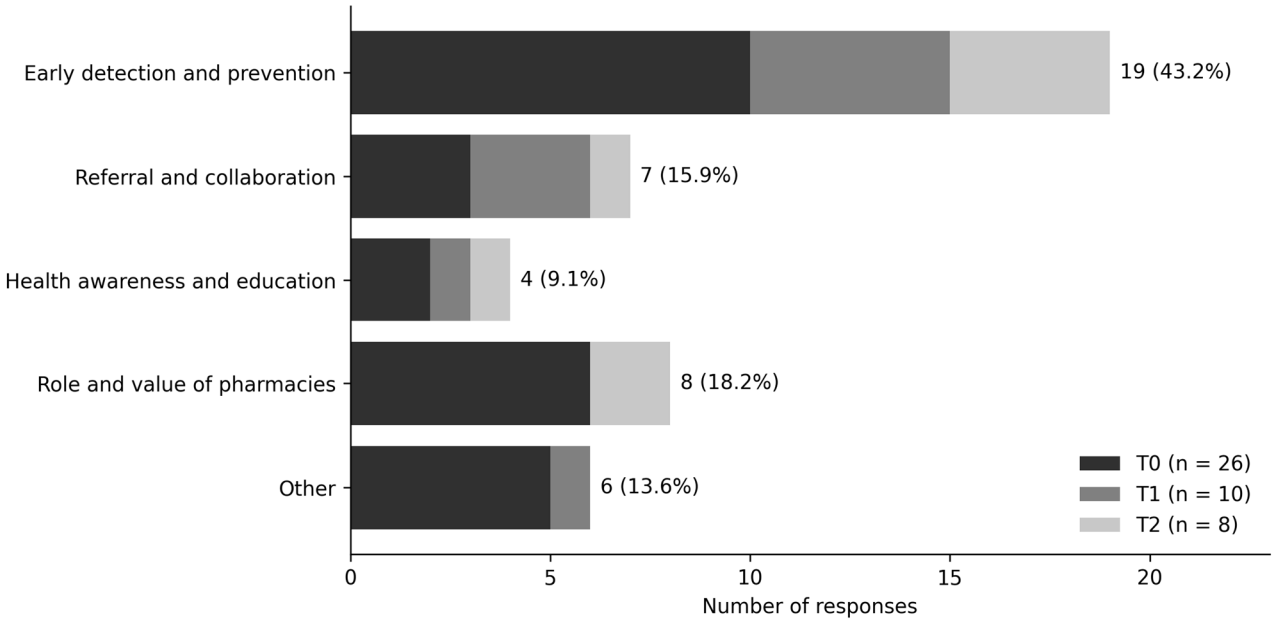


Figure 3. Categories of free-text responses by assessment time. One primary category per response. Totals and percentages use all 44 responses; the three time-specific denominators are 26, 10 and 8. Responses cannot be linked as within-pharmacist trajectories.

3.7. Screening Findings and Available Follow-Up

At the first screening, device categories were normal sinus rhythm in 313/332 (94.3%), bradycardia in two (0.6%), tachycardia in three (0.9%), possible AF in seven (2.1%), unclassified in three (0.9%), and analysis failed in four (1.2%). At the second screening, the corresponding counts were 212/223 (95.1%), one (0.4%), three (1.3%), one (0.4%), two (0.9%), and four (1.8%). Unclassified and failed analyses are indeterminate outputs, not diagnoses. Section S2.6 of Supplementary File S2 cross-tabulates all device categories and recorded actions.

Among the seven initial possible-AF recordings, four were accompanied by a medical consultation recommendation, two by an unaddressed referral letter and one by a health check-up recommendation. Information recorded in questionnaire free-text fields and other

available study records indicated a subsequent medical visit or health check-up for six residents and no visit for one. Four of the seven returned: two had normal sinus-rhythm outputs, one possible AF and one analysis failed; three did not return. One non-returning resident was reported to have begun cardiology treatment, but the diagnosis and treatment details were not verified. Another had a prior treated AF history, so the seven cannot be described as newly diagnosed AF. Section S2.11 of Supplementary File S2 gives case-level follow-up without direct identifiers. Confirmed diagnoses were outside the study scope; these reports do not establish AF diagnoses or diagnostic outcomes.

Across all first-round records, 32 health check-up recommendations, 11 medical consultation recommendations and three unaddressed referral letters were recorded (46/332; 13.9% combined). These are implementation process measures, not evidence of confirmed disease detection or clinical benefit.

4. Discussion

This study found increases in community pharmacists' self-assessed explanatory ability and preventive awareness during a programme integrating e-learning, AF screening and resident education. From T0 to T2, self-assessed ability to explain stroke and AF each increased from 3.30 to 4.26, and awareness of the importance of cardiovascular prevention increased from 3.78 to 4.78. All three changes remained statistically significant in exact conditional analyses with correction for the three comparisons within each item. In contrast, awareness of the importance of encouraging health check-ups increased from 4.56 to 4.78 without statistical significance, while perceived activity value increased from 4.11 to 4.48 but did not meet the corrected threshold under the exact analysis. The clearest finding is therefore improvement in three specific self-assessed outcomes, providing a basis for considering how structured learning and community practice may complement one another.

The timing of these changes helps clarify the educational relevance of the programme. Prevention awareness increased significantly immediately after e-learning (T0–T1), whereas self-assessed ability to explain stroke and AF increased significantly during the subsequent period of practical activities (T1–T2). The e-learning covered disease knowledge, the importance of cardiovascular prevention and pharmacy-based preventive care, while resident encounters provided opportunities to explain these topics in practice. Although the uncontrolled design cannot isolate the contribution of each component, the observed sequence is consistent with learning about prevention followed by opportunities to develop confidence in explaining it. High baseline awareness of health check-up importance (4.56/5) left relatively little room for improvement. Its non-significant change should therefore be considered alongside the high scores maintained throughout the programme.

Education studies in hypertension care [11,12] and smoking cessation [13] provide context for the changes in confidence and awareness observed here. Our findings extend this context to an integrated AF screening and resident education programme, in which all 27 pharmacists completed three assessments. The point-of-care testing trial [14] illustrates that educational gains and service delivery are distinct outcomes. Accordingly, the present findings concern pharmacists' perceived ability to explain stroke and AF, rather than independently demonstrated competence, and identify specific educational outcomes for future assessment using observed consultations or knowledge tests.

The combination of formal learning and resident encounters is compatible with practice-relevant continuing education and reflective professional development [15,17]. Experience explaining disease may contribute to perceived capability, as suggested by self-efficacy theory and pharmacy studies [18–20], although our programme-specific items do not constitute a validated self-efficacy scale and the mechanism was not tested. A review highlighting limited evidence on patient outcomes from community-pharmacy continuing

education [16] also supports evaluating self-assessment, recorded practice and clinical outcomes separately. Together, these perspectives support further development of education that connects structured content with repeated opportunities for resident communication.

Exploratory subgroup descriptions considered years of practice, degree curriculum, prescribing specialty and pharmacist role. Their purpose was to place the overall score changes in the context of differing professional backgrounds. With only 27 pharmacists and some single-person categories, these summaries cannot determine which groups benefit more or establish comparable educational effects. They provide a framework for larger studies to examine whether training needs and implementation support differ by professional experience or practice setting.

The increase in recorded health check-up recommendations is a potentially useful implementation finding. Among returning residents, recommendations rose from 7.6% to 22.4%, with 44 residents receiving a recommendation at the second round who had not received one at the first. This shows that repeat encounters provided additional opportunities for preventive advice. The resident-level paired analysis was statistically significant, but the pharmacy-clustered analysis was not (14.8 percentage points; 95% CI −4.7 to 34.3; $p = 0.129$). Two pharmacies accounted for 36 of the 44 newly recorded recommendations, so the increase cannot be interpreted as a consistent programme-wide behavioural effect. Differences in local implementation, recording and residents' needs may have contributed. Nevertheless, the observed expansion of advice in some pharmacies offers a practical starting point for examining which workflows and support could help other pharmacies incorporate preventive discussions into routine encounters.

The free-text analysis adds information about how pharmacists understood the purpose and practical value of pharmacy-based ECG activities. Early detection and prevention was the largest category (19/44 responses; 43.2%), followed by pharmacy role and value (8/44; 18.2%), referral and collaboration (7/44; 15.9%), and health awareness and education (4/44; 9.1%). The remaining six responses (13.6%) included operational burdens, eligibility limitations and neutral views. These themes describe a perceived pharmacy role extending beyond measurement to resident education and connection with medical care. Independent coding showed high agreement before consensus (93.2%; Cohen's $\kappa = 0.906$). Because 26 responses were collected at T0, 10 at T1 and eight at T2, and responses could not be linked within pharmacists, the themes cannot demonstrate a programme-induced change. They nevertheless help explain the relevance of preventive activities to participating pharmacists and identify practical issues to address when refining the programme.

The screening records provide further context for the educational activities. Across 332 initial encounters, pharmacists recorded 32 health check-up recommendations, 11 medical consultation recommendations and three unaddressed referral letters. Seven device outputs indicated possible AF; available records described a subsequent medical visit or check-up for six of these residents. These observations document opportunities to discuss prevention and connect residents with further care, while remaining distinct from verified diagnoses or clinical benefit. A later normal device output or a report of "no problem" does not exclude AF, and a preventive check-up is not equivalent to diagnostic evaluation. The different findings of STROKESTOP and LOOP further emphasise the importance of screening populations and downstream assessment [9,10]. Future implementation should therefore pair pharmacist education with clearer referral pathways and systematic follow-up, enabling both educational and resident outcomes to be evaluated.

One author represents the association that provided the e-learning programme and advised on questionnaire development. This relationship may influence programme expectations and interpretation. Questionnaire development was led by Nakamura and Ohmitsu; collection and access to identifiable responses were restricted to Nakamura, and the provider

had no such access. This arrangement limited provider access to responses but did not make the study an independent evaluation of the programme.

Limitations

The sample comprised 27 self-selected pharmacists in one urban ward, with no control group or a priori power calculation. The five outcomes were single self-assessed items rather than validated measures of objective competence; social desirability, response shift and awareness of study participation may affect responses. No pilot survey was conducted. The explanatory response labels at levels 2 and 4 overlap semantically even in Japanese, which limits measurement clarity; the original coding was retained. Multiple outcomes and exploratory post hoc analyses increase the risk of chance findings. Exact signed-rank inference still relies on the conditional sign-symmetry assumption and does not resolve design limitations. Volunteers may have had greater pre-existing interest in cardiovascular prevention, limiting generalisability.

Resident return was incomplete, pharmacy volumes varied markedly, and only 20 pharmacies contributed paired records. Cluster-adjusted inference is approximate, particularly with heterogeneous cluster sizes and concentrated changes. Baseline tests were not adjusted for clustering and should not be read as evidence of equivalence. Recorded action categories may not capture every action at an encounter, and recommendation need was not adjudicated. Check-up attendance was self-reported. Outcome information was limited to questionnaire free text and other available study records, so its completeness could not be established. Confirmed diagnoses were outside the study scope; treatment details and long-term outcomes were not independently verified. The workflow relied on device classifications without physician supervision and was not evaluated as a diagnostic or emergency-triage algorithm. Sparse pharmacist subgroups were summarised descriptively, and persistence of learning beyond programme completion was not evaluated. Screening was conducted within April–June and October–December windows rather than at a single fixed interval. Variation in intervals may have affected check-up attendance opportunities and subsequent recommendation needs.

Taken together, the findings support further development of a programme that links cardiovascular prevention education with opportunities to explain disease and provide preventive advice in community pharmacies. Future studies can build on the complete pharmacist follow-up and the observed changes in three self-assessed outcomes by adding validated measures, objective assessments and a comparison group. Examining the workflows of pharmacies with increased recommendations may also help translate local experience into practical support for broader implementation. This provides a constructive direction for strengthening community pharmacists' role in resident education and cardiovascular prevention.

5. Conclusions

Participation in an integrated e-learning, AF screening and community education programme was associated with significant T0–T2 increases in self-assessed ability to explain stroke and AF and awareness of cardiovascular prevention. Awareness of the importance of encouraging health check-ups remained high without a significant increase, and the increase in perceived activity value did not meet the corrected threshold in the exact analysis. Recorded check-up recommendations increased from 7.6% to 22.4% among returning residents, although the increase was concentrated in a few pharmacies and was not statistically significant after accounting for clustering. These findings do not establish causal effects or clinical benefit, but they identify promising educational outcomes and practical opportunities for preventive advice. Integrating structured learning with resident-facing

activities offers a promising approach for further development and controlled evaluation of community pharmacists' contribution to cardiovascular prevention.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/pharmacy14080174/s1. Supplementary File S1 (05_Supplementary_File_S1.xlsx) contains de-identified pharmacist scores, background characteristics, translated free text and coding. Supplementary File S2 (03_Supplementary_File_S2_Revised.docx) contains Sections S2.1–S2.11: resident questionnaires and leaflets, pharmacist instrument, coding definitions, ECG/action tables, descriptive subgroups, exact analyses and response distributions, pharmacy counts, time-specific free text and available possible-AF follow-up. An updated STROBE reporting map is supplied separately.

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Institutional Review Board Statement: The study was approved by the Ethics Committee of Daiichi University of Pharmacy (approval number R06-007; approval date: 10 January 2025).

Informed Consent Statement: Pharmacists received study information and provided informed consent before completing the baseline questionnaire (T0). Written consent was documented between 21 March and 1 April 2025, before resident-facing activities began. Participation was voluntary, withdrawal was permitted and refusal would not result in disadvantage. Written informed consent was also obtained from residents for ECG measurement, questionnaires, research use and repeated assessment, as described in Section 2.7.

Data Availability Statement: De-identified pharmacist data are provided in Supplementary File S1. Aggregate resident baseline comparisons, paired recommendation counts and pharmacy-level paired counts are provided in Table 3, Table 4 and Section S2.9, respectively. Resident dates of birth and local participant identifiers are not included in the submission package. Available case follow-up is summarised without direct identifiers in Section S2.11.

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Conflicts of Interest: Mitsuhiro Okazaki, representative director of the Smart HealthCare Association, facilitated provision of the e-learning programme and advised on the assessment design and questionnaire content. He also critically reviewed the manuscript for important intellectual content. He did not conduct the statistical analysis or draft the manuscript; the analysis and formulation of the results and conclusions were undertaken by the other investigators. This relationship with the programme provider is disclosed as a potential conflict of interest.

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