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Original Article

# High Prevalence of Atrial Fibrillation Found in the Capital of Greenland When Using Continuous Electrocardiogram Monitoring: A Cross-Sectional Study

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## ABSTRACT

**Background:** Atrial fibrillation (AF) increases the risk of conditions such as ischemic stroke, dementia, and heart failure, and early detection is crucial. In Greenland, ischemic strokes are common, and the prevalences of AF risk factors are increasing. Studies based on 30-second electrocardiograms (ECGs) and diagnosis codes so far have indicated either a low prevalence of AF or a prevalence comparable to that in other Western countries, such as Denmark. However, using short, single-point ECGs may underestimate the true prevalence, as especially paroxysmal AF can be missed. With this study, we aim to estimate the prevalence of AF using 3-5–day continuous Holter recordings among people in Nuuk, the capital of Greenland.

**Methods:** In this cross-sectional study, we estimated the prevalence of AF among the population aged ≥ 50 years in Greenland's capital, Nuuk. We used an ePatch to record continuous ECGs for 3-5 days, and questionnaires to assess demographic data, comorbidities, medication, symptoms, and risk factors for AF.

**Results:** Of 226 participants (62% women), 21 (33% women) had either self-reported AF, AF on the recording, or both, equivalent to a prevalence of 9.3% (confidence interval [CI] 5.8-13.9). The age-stratified prevalence was 7.2% (CI 2.7-15.1) among those aged 50-

## RÉSUMÉ

**Contexte :** La fibrillation auriculaire augmente le risque d'accidents vasculaires cérébraux (AVC) ischémiques, de démence et d'insuffisance cardiaque. Il est donc essentiel de la dépister rapidement. Au Groenland, les AVC ischémiques sont fréquents, et la prévalence des facteurs de risque de fibrillation auriculaire est à la hausse. Les études reposant sur des électrocardiogrammes (ECG) de 30 secondes et des codes de diagnostic ont jusqu'à présent révélé une faible prévalence de la fibrillation auriculaire ou une prévalence comparable à celle d'autres pays occidentaux, comme le Danemark. Cependant, l'utilisation d'ECG courts à un moment fixe dans le temps peut sous-estimer la prévalence réelle, car la fibrillation auriculaire paroxystique, en particulier, peut passer inaperçue. Cette étude a pour but d'estimer la prévalence de la fibrillation auriculaire en utilisant des enregistrements Holter continus de trois à cinq jours chez des habitants de Nuuk, la capitale du Groenland.

**Méthodologie :** Dans cette étude transversale, nous avons estimé la prévalence de la fibrillation auriculaire dans la population de ≥ 50 ans de Nuuk, la capitale du Groenland. Nous avons utilisé un timbre électronique pour enregistrer des ECG en continu pendant trois à cinq jours, ainsi que des questionnaires pour recueillir les données

Atrial fibrillation (AF) is a common arrhythmia, with a prevalence of 1%-4% globally.[1,2] The condition can be classified according to duration and treatment response, and by whether it is symptomatic or asymptomatic.[3] Paroxysmal AF is characterized by periods of AF lasting up to 7 days, interspersed with periods of normal sinus rhythm.[4] Persistent AF has periods of AF lasting longer than 7 days, whereas long-

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59 years; 8.8% (CI 4.1-16.1) among those aged 60-69 years; and 18.2% (CI 7.0-35.5) among those aged ≥ 70 years.

**Conclusions:** This study provides a novel insight into AF prevalence in Nuuk, emphasizing the potential underestimation in previous studies. Continuous ECG monitoring revealed a higher prevalence, especially among the younger age groups, urging a reevaluation of diagnostic practices in this unique population.

démographiques et consigner les maladies concomitantes, les médicaments, les symptômes et les facteurs de risque de fibrillation auriculaire.

**Résultats :** Sur 226 participants (dont 62 % étaient des femmes), 21 (33 % de femmes) présentaient, soit une fibrillation auriculaire autodéclarée, soit une fibrillation auriculaire selon l'enregistrement, soit les deux, ce qui correspond à une prévalence de 9,3 % (intervalle de confiance [IC] : 5,8 à 13,9). La prévalence stratifiée en fonction de l'âge était de 7,2 % (IC : 2,7 à 15,1) chez les 50 à 59 ans, de 8,8 % (IC : 4,1 à 16,1) chez les 60 à 69 ans et de 18,2 % (IC : 7,0 à 35,5) chez les 70 ans et plus.

**Conclusions :** Cette étude fournit de nouveaux renseignements sur la prévalence de la fibrillation auriculaire à Nuuk et souligne la prévalence potentiellement sous-estimée dans les études précédentes. La surveillance continue de l'ECG a révélé une prévalence plus élevée, en particulier dans les tranches d'âge plus jeunes, ce qui incite à réévaluer les pratiques de diagnostic utilisées dans cette population particulière.

standing persistent AF lasts longer than 12 months, and permanent AF is the condition reached when AF is accepted by the patient and no additional treatment or cardioversion is attempted.[3]

AF increases the risk of developing serious conditions, such as dementia and heart failure, and it is estimated to cause approximately 20% of all ischemic strokes (ISs).[5] The risk is higher among patients with persistent and permanent AF, and as paroxysmal AF can progress to being persistent or permanent,[4,6] detection and treatment ofthe condition as early as possible are important. However, paroxysmal AF can be missed on standard electrocardiograms (ECGs), and the recommended approach is that persons suspected of having AF be screened over longer periods of time or with multiple single-point ECGs, to increase the chance of identifying periods with AF.[3,7]

Estimates indicate that the European prevalence of AF will double from 2010 to 2060,[8] predominantly because of an increasing prevalence of some of the most well known risk factors for AF, including advanced age.[9-11] In fact, the incidence of AF has been shown to increase in parallel with age.[12] The fraction of the population in Greenland aged ≥ 50 years has increased from 18% in 2000 to 31% in 2023,[13] and well established AF risk factors, such as smoking, diabetes, and hypertension, are increasingly common among the population. The increasing prevalence of these risk factors and a high incidence of IS among young Greenlanders[14] create a pressing need to investigate the frequency of AF among the Greenlandic population.

Recent studies by our group have taken the first steps to do such investigation. In 2021, we estimated the prevalence of AF in Greenland to be at the same level as that in the Western countries, [15,16] although the prevalence of persistent AF was seemingly as low as 1% among Inuit on the Greenlandic East Coast.[16] However, these studies were based on either 30-second single-lead ECGs or diagnosis codes in the patients' medical records,[15,16] and short examination times and registration practices are limiting factors in these studies.

In this cross-sectional study, we aim to estimate the prevalence of AF in Greenland's largest city, Nuuk, by using 3-5days of Holter recordings among the general population aged ≥ 50 years. We thereby increase the chance of identifying AF among the study population and providing a more accurate estimate of the prevalence of AF in a unique population.

## Methods

### Setting

Greenland is a self-governing part of Denmark. Approximately 57,000 people live in Greenland—one third live in Nuuk, and the rest live in towns and settlements along the coast. The life expectancy is 69.6 years for men, and 73.5 years for women, and in 2022, a total of 17,208 inhabitants were aged ≥ 50 years.[13] Of the Greenlandic population, 87% is native to the island, and those making up the remaining portion were born primarily in Denmark.[13] No towns or settlements are connected by road, due to geology and climate, and transportation is done mainly by air or sea.

The Greenlandic healthcare system is based on the Danish system, meaning that diagnostics and treatment are free for permanent residents. Additionally, prescription medication is free for residents in Greenland. All larger towns have a healthcare centre with hospital facilities and at least one doctor or one or more nurses. The main hospital in the capital Nuuk is the only hospital offering intensive care, advanced treatment, and diagnostics, such as computed tomography and magnetic resonance imaging scans. Until 2023, the hospital was also the only place where Holter recordings were performed. Settlements have healthcare stations with trained staff, or in the larger ones, nurses. Telemedicine is widely and increasingly used in Greenland, and quality of care for chronic diseases is a major point of focus.

### Sample size

The sample size was calculated based on the prevalence of AF in East Greenland estimated from 12-lead ECGs conducted in the period 1962-1964,[17] and on the overall AF prevalence of 5.5% found among Caucasians in Heeringa

et al.'s study from 2006.[18] With a power of 80%, and an alpha of 0.05, the recommended study size was 177 persons to detect a prevalence of 2.5%.

## Recruitment

The study was conducted in Nuuk from April 2022 to January 2023. All Nuuk residents aged $\geq$ 50 years were eligible to participate in the study. Recruitment started 2 weeks before the testing and continued concurrently with the study for as long as time and equipment were available.

Participants were recruited via advertising in both Danish and Greenlandic on social media, in the Steno Diabetes Center Greenland in Nuuk, and on the Ilisimatusarfik University (University of Greenland) homepage. The local radio and the freely distributed weekly newspaper also featured information on the project in both languages, and people interested in participating could contact the investigator (N.A.) directly by either phone or e-mail, to be included. In addition, S.A. was provided a list of names and addresses of residents in Nuuk aged $\geq$ 50 years by December 2021 from the local authorities (Kimik iT A/S, Nuuk, Greenland), and the public phone register (tusass.gl) was used to find their phone numbers. Finally, participants with type 2 diabetes included in an obstructive sleep apnea study by M.M.J. and M.L.P. at Steno Diabetes Center Greenland were invited to participate.

Eligible participants were informed in writing in both Danish and Greenlandic, and a Danish video with Greenlandic subtitles explaining and showing the study protocol was accessible on the Ilisimatusarfik University homepage and the social media channels of the Steno Diabetes Center Greenland. A professional Danish–Greenlandic translator was present during phone calls and examinations, per participant wishes. N.A. informed and conducted the studies between April and July 2022, and M.M.J. informed participants and conducted the studies from July 2022 and January 2023.

## Test procedures

**Holter.** Holter monitoring were performed using the ePatch system (BioTel Europe AB). [19,20] The ePatch was attached to the manubrium sternum after shaving (if needed) and disinfection of the skin area. The ePatch recorded for 3-5 days, and the participants were carefully instructed to avoid water immersion but encouraged to partake in their normal daily activities, including sports. When feasible, a fresh recording was started if the ePatch came loose or had a malfunction prior to the 3 days passing. The recordings were saved by participant number on the secure server of Aalborg University (Aalborg, Denmark).

**Symptoms.** The participants were instructed to note any cardiac or respiratory symptoms they experienced while wearing the ePatch, including time of debut, duration, and activity while experiencing the symptoms.

**Blood pressure.** Blood pressure was measured with an electronic sphygmomanometer after participants had had 10 minutes of rest. Participants with 2 or more measurements indicating hypertension (> 140/90 mm Hg) were encouraged to have a follow-up at the local healthcare centre.

**Questionnaire.** A questionnaire was available in both Danish and Greenlandic and was filled out by the participant either directly into REDCap (version 13.1.37, Vanderbilt University, Nashville, TN)[21,22] or on paper. The paper questionnaires were later entered into REDCap by N.A.. Data asked for in the questions included the following: age; height; weight; gender; smoking status; previous and current illnesses; family medical history (thyroid disease, diabetes, and hypertension); current medication; and symptoms of AF within the 3 months before the test (palpitations, irregular heart rate, slow heart rate, chest pain, faintness, dizziness, shortness of breath). Participants were asked about their parents' country of birth, as having at least 1 parent born in Greenland was used as a proxy for being of Inuit origin.

**$CHA_2DS_2$-VASc score.** A **C**ongestive Heart Failure, **H**ypertension, **A**ge $\geq$ 75 Years, **D**iabetes Mellitus, **S**troke, **V**ascular Disease, **A**ge 65 to 74 Years, **S**ex **C**ategory ($CHA_2DS_2$-VASc) score was calculated for each participant based on the information provided in the questionnaires. The $CHA_2DS_2$-VASc score is an international validated tool used to estimate AF patients' risk of stroke. Generally, a score of zero is considered low risk, whereas oral anticoagulation treatment (OAC) should be considered when the score is $\geq$ 1.[23]

## Analyses and statistics

The ePatch-recordings were analyzed using Cardiologs software (Cardiologs Technologies Inc., Cambridge, MA) by a nurse employed by BioTel Europe. N.A. verified all reports and recordings, and any unclarities were discussed with the nurse and a consultant cardiologist who specialized in arrhythmias (S.R.). AF was defined as at least 30 continuous seconds of irregular RR waves and lack of discernible P waves on the ECG recording.

After the analyses of the recordings, participants were informed directly about the result of their individual test by N.A. or M.L.P., and participants with non-normal recordings were offered a consultation at Steno Diabetes Center Greenland, and, if necessary, a follow-up by a cardiologist at Queen Ingrid's Hospital in Nuuk. These follow-ups were done after the study concluded, and the results therefore are not included in this article. Patients who had answered "yes" to having an arrhythmia in the questionnaire were interviewed for further details, and the response was adjusted if appropriate. The research team did not have access to the participants' medical journal for verification of the diagnoses.

All data from the ePatch reports and participant questionnaires were entered into REDCap and analyzed in STATA (version 16.1, StataCorp LLC, College Station, TX). If the participant reported a documented diagnosis of AF, but did not have AF on the ePatch recording, the participant was registered in the study as having AF.

Continuous data were tested for normality using the Shapiro–Wilk test for normality, QQ-plots and histograms, and, if normally distributed, were described with means and standard deviations. If not normally distributed, the data were described with medians and interquartile ranges (IQRs). Categorical data were described with percentages, and prevalences were estimated with 95% confidence intervals (CIs). Missing data and statistical tests are described below each table.

## Results

A total of 214 individuals proactively contacted the research team to participate. Additionally, 39 participants were approached during their involvement in another study at Steno Diabetes Center Greenland. Of the 5398 residents in Nuuk aged ≥ 50 years, 518 individuals had publicly available phone numbers. As spots in the study filled up quickly, only 72 of them were contacted and invited to participate. Figure 1 shows the process of inclusion and exclusion of participants.

A total of 226 participants completed the study with an analyzable ePatch recording. Sixteen participants were recruited by phone, 178 through social media and/or other media, and 32 from the other study. A total of 21 participants reported having AF in the questionnaire, but the number was reduced to 18 (8% of all participants) after further details were obtained from the participants. The participants' characteristics are shown by gender in Table 1.

Specifics of the ePatch recordings are shown in Table 2. The median ePatch recording time for the participants was 6224 minutes (4.3 days), and the recording time was 3 days or longer for 193 participants (85%). No difference occurred in the recording time between participants with vs without AF, as shown in Table 2.

Nine men and one woman had AF on their ePatch recording. Three of the men were not diagnosed previously with AF, bringing the total number of participants with AF to 21 (7 women, 14 men), equivalent to a prevalence of 9.3% (CI 5.8-13.9) in the study population. None of the 3 new cases had persistent AF on their recording (data not shown). All 3 new cases of AF were found among participants recruited through social media and/or other media. In total, 18 of the AF patients were found in the group recruited through social media, 3 among those recruited from a different study, and none among the participants recruited by phone ($P = 0.575$; data not shown).

When straifying for age, the estimated prevalence was 7.2% (CI 2.7-15.1) among those aged 50-59 years, 8.8% (CI 4.1-16.1) among those aged 60-69 years, and 18.2% (CI 7.0-35.5) among those aged ≥ 70 years. The characteristics of all participants with AF are shown and are compared to those of participants without AF in Table 3.

The median $CHA_2DS_2$-VASc score was 1, among both participants with vs without AF (Table 3). Of the 18 participants who reported having AF before the recording, 12 had a $CHA_2DS_2$-VASc score of ≥ 1. Among these participants, 5 were on anticoagulation treatment (rivaroxaban or warfarin). None of the participants with AF and a $CHA_2DS_2$-VASc score of zero prior to the study was treated with an OAC.

During recording, 51 participants (25%) without AF reported symptoms—1 participant (33%) who was not previously diagnosed but had AF on the recording, 5 (45%) of the participants diagnosed with AF but without AF on the recording, and 2 (29%) of the participants who had both an AF diagnosis and AF on the recording ($P = 0.72$). Palpitations were the most common symptom and were reported by 6 participants with AF (29%) and 29 participants without AF

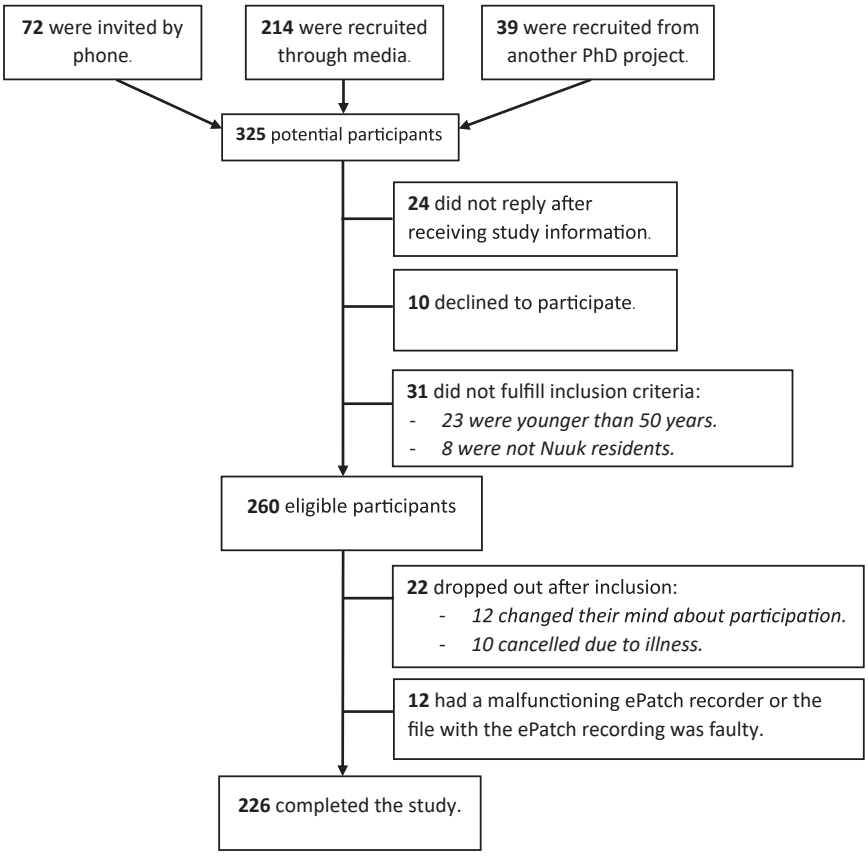


**Figure 1.** Process for Inclusion and exclusion of study participants.

**Table 1.** Participant characteristics

| Characteristic | Men (n = 86) | Women (n = 139) | Total (n = 226)* | *P* |
|---|---|---|---|---|
| Age, y, median (IQR) | 62 (10) | 61 (10) | 61 (10) | 0.22 |
| BMI, kg/m2, median (IQR) | 28 (6.4) | 29 (8.7) | 28 (7.6) | 0.99 |
| Active smoker | 22 (17 of 82) | 27 (35 of 133) | 25 (53 of 216) | 0.16 |
| Consumes alcohol weekly | 66 (54 of 82) | 61 (80 of 132) | 62 (134 of 215) | 0.18 |
| Systolic BP, mm Hg, median (IQR) | 145 (246) | 139 (23) | 141 (24) | 0.17 |
| Diastolic BP, mm Hg, mean (SD) | 88 (12) | 83 (11) | 85 (12) | 0.003 |
| Pulse, bpm, mean (SD) | 75 (13) | 78 (11) | 77 (12) | 0.07 |
| Greenlandic origin | 78 (66 of 85) | 90 (120 of 133) | 85 (186 of 219) | < 0.01 |
| Family history of cardiac disease | 41 (34 of 83) | 54 (73 of 134) | 49 (107 of 218) | 0.06 |
| Comorbidities, self-reported | | | | |
| AF | 13 (11 of 83) | 5 (7 of 134) | 8 (18 of 218) | 0.15 |
| Ischemic heart disease | 3 (3 of 83) | 0 (0 of 134) | 1 (3 of 218) | 0.07 |
| Heart failure | 4 (3 of 83) | 0 (0 of 134) | 1 (3 of 218) | 0.07 |
| Pacemaker | 2 (2 of 83) | 1 (2 of 134) | 2 (4 of 218) | 0.64 |
| Hypertension | 36 (30 of 83) | 33 (43 of 132) | 34 (73 of 216) | 0.77 |
| Diabetes | 29 (24 of 83) | 15 (20 of 132) | 21 (45 of 216) | 0.01 |
| Thyroid disease | 5 (4 of 83) | 8 (11 of 133) | 7 (15 of 215) | 0.46 |
| Symptoms within the last 3 months before the test, self-reported | 68 (56 of 82) | 80 (105 of 131) | 75 (161 of 214) | 1.00 |
| Irregular pulse | 30 (24 of 79) | 41 (53 of 129) | 37 (77 of 209) | 0.18 |
| Palpitations | 24 (19 of 79) | 57 (73 of 129) | 44 (92 of 209) | < 0.01 |
| Pauses in heart rate | 19 (15 of 79) | 18 (23 of 129) | 18 (38 of 209) | 0.88 |
| Chest pain when resting | 28 (22 of 79) | 19 (25 of 129) | 22 (47 of 209) | 0.36 |
| Shortness of breath | 25 (20 of 79) | 29 (37 of 129) | 27 (57 of 209) | 0.73 |
| Faintness | 37 (29 of 79) | 44 (57 of 129) | 41 (86 of 209) | 0.42 |
| Dizziness | 8 (6 of 79) | 9 (11 of 129) | 8 (17 of 209) | 1.00 |
| Medication, self-reported | | | | |
| Rate- and/or rhythm control | 16 (13 of 82) | 11 (14 of 132) | 13 (27 of 215) | 0.38 |
| Beta-blocker | 16 (13 of 82) | 11 (14 of 132) | 12 (26 of 215) | 0.38 |
| Verapamil | 0 | 0 | 0 | — |
| Diltiazem | 0 | 0 | 0 | — |
| Digoxin | 0 (0 of 82) | 1 (1 of 132) | 0 (1 of 215) | 1.00 |
| Amiodarone | 1 (1 of 82) | 0 (0 of 132) | 0 (1 of 215) | 0.39 |
| Flecainide | 1 (1 of 82) | 0 (0 of 134) | 0 (1 of 215) | 0.39 |
| Antihypertensives,† | 35 (39 of 82) | 33 (43 of 132) | 33 (72 of 215) | 0.84 |
| Statins | 26 (21 of 82) | 14 (19 of 132) | 19 (41 of 215) | 0.02 |
| Antidiabetics | 22 (18 of 82) | 10 (13 of 132) | 15 (32 of 215) | < 0.01 |
| Platelet inhibitors | 11 (9 of 82) | 5 (6 of 132) | 7 (15 of 215) | 0.16 |
| OAC | 7 (6 of 82) | 4 (5 of 132) | 5 (11 of 215) | 0.38 |
| Antithyroid medication | 0 (0 of 82) | 2 (2 of 132) | 1 (2 of 215) | 0.53 |
| Thyroid hormone replacement | 0 (0 of 82) | 3 (4 of 132) | 2 (4 of 215) | 0.31 |

Unless otherwise indicated, values are % (yes-sayers per number of responses); for these data, difference was tested with the Fischer exact test. For data reported as median (interquartile range [IQR]), difference was tested with the Wilcoxon Mann-Whitney test. For data reported as mean (standard deviation [SD]), difference was tested with the Student *t* test.

AF, atrial fibrillation; BMI, body mass Index; BP, blood pressure; bpm, beats per minute; OAC, oral anticoagulant.

*One participant did not wish to disclose their gender.

†Does not include beta-blockers.

(14%). Shortness of breath was reported by 1 participant with AF (0.5%) and 4 participants without AF (2%). Finally, chest pain when resting was reported by 1 participant with AF (0.5%), and 14 participants without AF (7%), and dizziness was reported by 2 participants without AF only (1%).

## Discussion

This study sheds new light on the prevalence of AF in Greenland. Using continuous ECG recordings with a median recording time of 4.3 days, we estimated the prevalence of AF to be 9.3% among the population in Nuuk aged ≥ 50 years, increasing from 7.2% among those aged 50-59 years, and to 18.2% among those aged ≥ 70 years.

Our results indicate a high prevalence of AF compared to that in other Nordic countries, especially among the younger age groups. In Denmark, the prevalence of AF, based on registered diagnosis codes, between 1994 and 2018 was 1.0% among those aged 55-59 years, increasing to 8.5% among those aged 75-79 years, and 22.5% among those aged 95-99 years.[24] In Finland, the prevalence of AF, similarly based on diagnosis codes, is approximately 3% among those aged 55-60 years; however, this prevalence steeply increased to 23.4% among those aged > 75 years.[25]

Little information has been gathered on the age-stratified prevalence among other Arctic populations, but the risk of incident AF has been found to be highest among Native Americans and Alaska Natives, compared to the risk among Whites, Blacks, Asians, and Hispanics over a 6-year period in California.[26] Similarly, the incidence and prevalence was higher among the Canadian Métis, compared to those in the general population in Ontario.[27] In Australia, the overall prevalence of AF was found to be higher among hospitalized Indigenous patients, compared to that among nonIndigenous patients, and up to 4 times higher among those aged 45-54 years.[28]

**Table 2.** Characteristics of ePatch recordings by AF diagnosis and AF on ePatch recording

| Characteristic | No AF (n = 205) | Diagnosed with AF, but no AF on recording (n = 11) | Diagnosed with AF, and AF on recording (n = 7) | Not diagnosed with AF, but AF on recording (n = 3) | *P* |
|---|---|---|---|---|---|
| Total recording time, min | 5608 (1375) | 5556 (1464) | 5943 (1163) | 6480 (0) | 0.38 |
| Analyzable recording time, min | 5030 (1471) | 4763 (1754) | 4639 (949) | 5928 (903) | 0.46 |
| Noise, % | 0.07 (0.46) | 0.27 (6.36) | 0.01 (0.84) | 0.01 (0.02) | 0.05 |
| Max HR, bpm, mean (SD) | 141 (17) | 132 (15) | 129 (23) | 175 (8) | 0.4 |
| Min HR, bpm, mean (SD) | 55 (10) | 55 (10) | 49 (10) | 47 (6) | 0.81 |
| Average HR, bpm, mean (SD) | 79 (10) | 79 (11) | 76 (13) | 77 (4) | 0.4 |
| Median number of pauses | 0 (0) | 0 (0) | 3 (82) | 0 (0) | < 0.01 |
| PSVCs, total | 100 (323) | 158 (537) | 699 (563) | 381 (12846) | 0.24 |
| PVCs, total | 30 (367) | 207 (847) | 327 (548) | 335 (885) | 0.05 |
| SVESs, % per h | 0.02 (0.07) | 0.05 (0.1) | 0.0 (0.01) | 0.08 (3.24) | 0.04 |
| VESs, % per h | 0.01 (0.08) | 0.18 (0.32) | 0.1 (0.13) | 0.08 (0.17) | < 0.01 |
| Mean HRV, ms | 767 (136) | 775 (180) | 850 (330) | 8209 (56) | < 0.69 |

Unless otherwise indicated, data are reported as median (interquartile range); for these data, difference was tested with the Kruskal–Wallis test. For data reported as mean (standard deviation [SD]), difference was tested with one-way analysis of variance.

AF, atrial fibrillation; bpm, beats per minute; HR, heart rate; HRV, heart rate variability; max, maximum; min, minimum; PSVC, premature supraventricular complex; PVC, premature ventricular complex; SVES, supraventricular extrasystole; VES, ventricular extrasystole.

Our current results also stand in contrast to those found in previous studies from Greenland, which showed a lower estimated prevalence of AF. A study based on single-point 12-lead ECGs from 1963 found a prevalence of 0.6% among 181 adults aged ≥ 40 years,[17] and similarly, a study based on recordings from 2019 by a handheld single-lead ECG device found an AF prevalence of 1% among 220 participants aged ≥ 50 years.[16] Finally, a study from 2021 based on diagnosis codes and prescribed OACs identified 790 patients with AF in Greenland, corresponding to a prevalence of 1.4%, increasing to 11% among those aged > 70 years.[15]

ECG recordings for a 70-hour period increase the detection rate of AF more than 2-fold, compared to 24-hour monitoring.[29] A reason for the difference in the prevalence between this study and the previous studies therefore could be explained by the change of method, as participants with paroxysmal AF may have been missed in the previous studies, which were based on single-point ECGs. A high rate of undiagnosed AF was found in Greenland in 2012, when a study evaluated the results of Holter recordings performed among IS patients. The study found that only 7 of 45 patients with AF had been diagnosed before being admitted with stroke.[30] A follow-up study, conducted in 2022, found fewer cases of AF among IS patients in Greenland; however, only 46% of the patients had a Holter recording performed according to international standards. In addition, the ratio of IS patients who had a Holter recording performed dropped to as low as 27% and 17% in 2018 and 2019, respectively, due to malfunctioning equipment, and the possibility that other patients suspected of having AF may not have had a Holter recording performed during those years cannot be ruled out either. International guidelines recommend that patients who have suffered an IS be monitored for at least 72 hours, to increase the chance of identifying AF,[3] and 85% of our study population reached that recommendation, increasing the chance of capturing AF in our study.

Additionally, recording continuous ECGs on participants without symptoms increases the chance of identifying asymptomatic AF. Asymptomatic AF, or silent AF, is common, and it may account for up to 40% of all cases of AF,[31,32] although this may differ by ethnicities.[33] In our study, 32% of the participants with AF did not report having symptoms within the 3 months of the study, as was the case for 1 of 3 participants who had not been diagnosed before the study (data not shown). Our results are in line with those of the study by Verbiest-van Gurp et al. study in Holland, in which symptoms triggered an examination for AF in 64.7% of patients subsequently diagnosed with AF in general practice, stroke was the trigger in 3.5%, and the diagnosis was incidental in 31.5%.[34] Therefore, including participants without symptoms identified AF among patients who might have been missed in everyday daily practice and were therefore not included in the study from Greenland describing AF prevalence based on diagnosis codes.[15]

However, selection bias poses a risk of having caused some overestimation of the prevalence in this current study. Participants volunteered to participate, almost half had a family history of cardiac disease, and 8% reported having AF on the questionnaire. In addition, 75% of the study participants reported having symptoms that could be related to AF in the 3 months leading up the study, most commonly palpitations. The prevalence of palpitations among the general population in Greenland is unknown, but it accounts for as many as 16% of visits in general practice in Europe, and cardiac disease is the most common cause of the symptoms.[35] However, the prevalence of most comorbidities that predispose patients to AF are at the same level among our study population, compared to that among the general population in Greenland. The number of participants with thyroid disease is at the same level as that described by Noahsen et al. in 2021[36]; 33% of the participants in our study were treated with an antihypertensive, whereas this was the case among 21% of those aged 50-59 years in Greenland in 2021, a prevalence that increased to 81% among those aged ≥ 80 years.[37] Similarly, heart failure was reported by 1%, which corresponds to the prevalence described by Larsen et al. in 2023,[38] and the self-reported prevalence of ischemic heart disease is similar to that found by Jørgensen et al. in a study including 1316 Greenlandic Inuit participants aged ≥ 18 years.[39] Regarding diabetes, 21% of those in our study reported having this condition, a prevalence that is higher than that among those aged 70-79 years in Greenland, the group that has the highest prevalence of diabetes, at 15%. This overrepresentation of participants with diabetes in our study likely is explained by

**Table 3. Characteristics of participants with vs without AF**

| Characteristic | AF (n = 21) | No AF (n = 205) | *P* |
|---|---|---|---|
| Male gender | 67 (14 of 21) | 35 (72 of 205) | 0.01 |
| Age, y, median (IQR) | 62 (12) | 61 (10) | 0.18 |
| BMI, kg/m2, median (IQR) | 31 (5.4) | 28 (7.2) | 0.07 |
| Active smoker | 20 (4 of 20) | 25 (49 of 196) | 0.43 |
| Consumes alcohol weekly | 75 (15 of 20) | 61 (119 of 195) | 0.67 |
| Systolic BP, mm Hg, median (IQR) | 140 (28) | 141 (24) | 0.53 |
| Diastolic blood pressureBP Hg, mean (SD) | 83 (9) | 85 (12) | 0.64 |
| Pulse, bpm, mean (SD) | 75 (12) | 78 (12) | 0.33 |
| Greenlandic origin | 85 (18 of 21) | 85 (168 of 198) | 0.61 |
| Family history of cardiac disease | 33 (7 of 21) | 51 (100 of 197) | 0.10 |
| $CHA_2DS_2$-VASc score, median (IQR)* | 1 (2) | 1 (2) | 0.41 |
| Comorbidities, self-reported | | | |
| AF | 86 (18 of 21) | 0 (0 of 197) | < 0.01 |
| Ischemic heart disease | 0 (0 of 21) | 2 (3 of 197) | 0.74 |
| Heart failure | 9.5 (2 of 21) | 1 (1 of 197) | 0.03 |
| Pacemaker | 9.5 (2 of 21) | 1.0 (2 of 197) | 0.047 |
| Hypertension | 48 (10 of 21) | 32 (63 of 195) | 0.12 |
| Diabetes | 14 (3 of 21) | 21 (41 of 196) | 0.37 |
| Thyroid disease | 10 (2 of 21) | 7 (13 of 196) | 0.44 |
| Symptoms within the last 3 months before the test, self-reported | 63 (16 of 19) | 74 (141 of 190) | 0.66 |
| Irregular pulse | 68 (13 of 19) | 34 (64 of 190) | < 0.01 |
| Palpitations | 47 (9 of 19) | 44 (83 of 190) | 0.47 |
| Pauses in heart rate | 42 (8 of 19) | 16 (30 of 190) | 0.01 |
| Chest pain when resting | 37 (7 of 19) | 21 (40 of 190) | 0.10 |
| Shortness of breath | 42 (8 of 19) | 26 (49 of 190) | 0.11 |
| Faintness | 47 (9 of 19) | 41 (77 of 190) | 0.37 |
| Dizziness | 11 (2 of 19) | 8 (15 of 190) | 0.47 |
| Medication, self-reported | | | |
| Rate- and/or rhythm control | 47 (9 of 19) | 9 (18 of 196) | < 0.01 |
| Beta-blocker | 47 (9 of 19) | 9 (18 of 196) | < 0.01 |
| Verapamil | 0 | 0 | - |
| Diltiazem | 0 | 0 | - |
| Digoxin | 5 (1 of 19) | 0 (0 of 196) | 0.09 |
| Amiodarone | 5 (1 of 19) | 0 (0 of 196) | 0.09 |
| Flecainide | 5 (1 of 19) | 0 (0 of 196) | 0.09 |
| Antihypertensives† | 42 (8 of 19) | 33 (64 of 196) | 0.28 |
| Statins | 5 (1 of 19) | 20 (40 of 196) | 0.09 |
| Antidiabetics | 11 (2 of 19) | 15 (30 of 196) | 0.44 |
| Platelet inhibitors | 11 (2 of 19) | 7 (13 of 196) | 0.39 |
| OAC | 26 (5 of 19) | 3 (6 of 196) | < 0.01 |
| Antithyroid medication | 5 (1 of 19) | 1 (1 of 196) | 0.17 |
| Thyroid hormone replacement | 0 (0 of 21) | 2 (4 of 196) | 0.69 |

Unless otherwise indicated, values are % (yes-sayers per number of responses); for these data, difference was tested with the Fischer exact test. For data reported as median (interquartile range [IQR]), difference was tested with the Wilcoxon Mann–Whitney test. For data reported as mean (standard deviation [SD]), difference was tested with the Student *t* test.

AF, atrial fibrillation; BMI, body mass index; BP, blood pressure; bpm, beats per minute; $CHA_2DS_2$-VASc, **C**ongestive Heart Failure, **H**ypertension, **A**ge ≥ 75 Years, **D**iabetes Mellitus, **S**troke, **V**ascular Disease, **A**ge 65 to 74 Years, **S**ex **C**ategory; OAC, oral anticoagulant.

* Female participants with no risk factors other than gender were given a score of zero.

† Does not include beta-blockers.

the recruitment of patients from Steno Diabetes Center Greenland in Nuuk. However, the ratios of participants with diabetes were the same in the AF and the non-AF group in our study, in which the presence of heart failure and a pacemaker were the 2 conditions more often present among those with AF.

Another risk is that selection bias caused some underestimation of the prevalence. In Nuuk, 54% of the population aged ≥ 50 years are men,[13] but in our study, 62% of the study population were women (Table 1). Men have a higher incidence of AF than do women,[9,40] although lifetime risk may be the same for both genders, owing to women living longer in general.[41,42] The same trend has been found in a previous study from Greenland, in which the prevalence of diagnosed AF was doubled among men, compared to that among women, until age 70 years.[15] In this current study, 67% of the participants with AF were men, and we may have identified more cases had the gender distribution been more equal.

Finally, AF can be hereditary, and certain genes have been linked to an increased risk of developing AF.[43] Our study did not include genetic data, but a well established finding is that the Greenlandic Inuit population has genetic traits that increase the risk of type 2 diabetes, and higher levels of cholesterol and triglycerides.[44,45] In addition, a study from Canada found a higher rate of congenital QT syndrome among some First Nations participants,[46] and the Inuit population in Greenland has a higher rate of congenital heart disease and nonischemic heart failure than that among the non-Inuit population,[38,47,48] all of which can create a predisposition for AF. Some ethnic minorities may have an increased susceptibility to early-onset AF due to genetic variants,[49] and we found an AF prevalence of 7% among the youngest agegroup included in our study. As IS has been found previously to be more incident among younger age groups in Greenland,[14] the potential link of early-onset AF with IS in Greenland could be a topic for future studies.

## Strengths and Limitations

This study is the first to describe AF prevalence in the general population in Greenland based on continuous ECG recordings, providing prolonged and comprehensive assessments of the participants' cardiac rhythm, and limiting the risk of missing paroxysmal AF. This study is also the first in Greenland to describe symptoms occurring both before and during the recording period.

The limited number of participants, and especially participants with AF, limits our ability to compare participants with vs without AF, in regard to symptoms and demographic data, and to compare the prevalence across age-groups, as evidenced by the wide CIs of the age-stratified prevalences mentioned in the results. In addition, we did not have access to the participants' medical records, and consequently, most of the health data used in the study are self-reported. Some data therefore may be imprecise, underreported, or overreported.

The participants in our study did not have standard 12-lead single-point ECGs performed during the recording period. Therefore, whether some of the new cases of AF would have been detected without a continuous recording is unknown.

Due to imprecise timestamps, our data do not allow us to compare patterns on the ECG recordings directly with symptoms registered by the participants. Unfortunately, this situation inhibits us from connecting symptoms with both periods of AF and other registered cardiac rhythms not described in this study.

Although some cardiac morbidity is known to be more common among the Inuit population, our study includes both participants with Inuit and those with non-Inuit ethnicity, and any conclusion as to whether AF is common among Inuit in general should be drawn with great care, as the study population is quite small. In addition, people with a family history of cardiac disease or symptoms of cardiac disease may have been more motivated to participate in the study, resulting in selection bias.

Due to the cross-sectional study design, we are not able to identify changes over time or causation of AF. Finally, our study does not disclose information on socioeconomic or cultural context of symptoms or development of AF.

## Conclusion

Despite having some limitations, this study provides a pioneering assessment of AF prevalence in Greenland, shedding light on a higher-than-expected prevalence, compared to that in other populations and previous studies from Greenland. Future research should address the identified limitations and explore the potential genetic and demographic factors contributing to the observed prevalence. Also, our data emphasize the importance of using continuous ECG recordings when detecting AF, including in remote areas.

## Data Availability

The data used in this article will be shared upon reasonable request to the corresponding author.

## Ethics Statement

The study was approved by the Health Research Ethics Committee and the health authorities in Greenland (KVUG 2020-18), and was conducted according to the Helsinki declaration. A data processing agreement (case number 2022-035370) was signed by Aalborg University Hospital and BioTel Europe AB before the ePatch files were uploaded to and analyzed by BioTel Europe AB. All participants received oral and written information prior to the study.

## Patient Consent

The authors confirm that patient consent forms have been obtained for this article.

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## Disclosures

The authors have no conflicts of interest to disclose.

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