Social determinants of atrial fibrillation

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Abstract

Atrial fibrillation affects almost 60 million adults worldwide. Atrial fibrillation is associated with a high risk of cardiovascular morbidity and death as well as with social, psychological and economic burdens on patients and their families. Social determinants — such as race and ethnicity, financial resources, social support, access to health care, rurality and residential environment, local language proficiency and health literacy — have prominent roles in the evaluation, treatment and management of atrial fibrillation. Addressing the social determinants of health provides a crucial opportunity to reduce the substantial clinical and non-clinical complications associated with atrial fibrillation. In this Review, we summarize the contributions of social determinants to the patient experience and outcomes associated with this common condition. We emphasize the relevance of social determinants and their important intersection with atrial fibrillation treatment and outcomes. In closing, we identify gaps in the literature and propose future directions for the investigation of social determinants and atrial fibrillation.

Atrial fibrillation (AF) is the most commonly encountered cardiac rhythm disorder, affecting nearly 60 million adults worldwide in 2019 and contributing to substantial social and medical burdens[1,2]. AF is associated with myriad cardiovascular and non-cardiovascular outcomes, including well-recognized outcomes such as heart failure, myocardial infarction, ischaemic stroke and death, as well as frailty, cognitive decline and high health-care utilization[3]. Social determinants of health contribute to the recognition, evaluation, treatment and outcomes of diverse disease states but have had limited examination in AF. Given their

relevance to multiple risk factors for cardiovascular disease and AF, social determinants of health have substantive roles in the patient experience of AF, access to care, health outcomes and social burden.

Social determinants of health are the circumstances into which an individual is born and in which the individual lives, works and plays, and which together influence health and health care[4,5]. Social determinants of health include race and ethnicity, financial resources, social support, access to health care, residential environment, proficiency in the local language and health literacy. Each of these factors has a prominent role in provider-level evaluation and management of all diseases, including AF, as well as in how individuals experience their health conditions (Fig. 1). Despite their fundamental importance, to date, critical evaluation of social determinants of health in relation to AF has been limited.

In this Review, we define the multiple contributions of social determinants to the patient experience and outcomes associated with AF, identify gaps and challenges in the literature on the associations between AF and social determinants, and articulate future directions to address these deficits. We further discuss the relevance and importance of integrating social determinants in clinical trials and observational studies on AF to advance the achievement of equitable outcomes in this condition. Although much of the literature cited in this Review is based on studies led in the USA, mostly because of the racial/ethnic, sociodemographic and geographical diversity of the country, we include data from other regions to highlight that addressing the social determinants of health is crucial to the global prevention and management of AF.

Race and ethnicity

Race and ethnicity have been the most studied social determinants of cardiovascular health. Prominent research consistently demonstrates the influence of pervasive racial bias and discrimination both within and beyond medical care[6–9]. Racial inequities in health and health care have, therefore, been widely described across cardiovascular conditions, including AF[10–12]. Despite the availability of studies aimed at addressing these disparities, in the USA, the rate of death from cardiovascular disease remains 20% higher in Black Americans than in white Americans[13] (Box 1). How race and ethnicity influence AF is observed across the multiple dimensions of the disease, extending from AF recognition to clinical evaluation and management, as well as to short-term and long-term outcomes[14,15] (Fig. 2).

Race, ethnicity and AF incidence.

Despite a preponderance of clinical risk factors for AF, such as hypertension, diabetes mellitus, obstructive sleep apnoea and obesity, in individuals from under-represented racial and ethnic groups in the USA, multiple analyses have shown lower rates of AF in Black Americans, Hispanic or Latino (further referred to as Hispanic) Americans, Asian Americans and Native Americans than in white Americans[16–19]. In the ARIC study[20], a biracial, community-based cohort of >15,000 participants conducted in four US cities, the lifetime risk of developing AF over 25 years of follow-up was ~33% among white Americans compared with ~20% among Black Americans. Lower rates of AF in Black

Americans than in white Americans were also observed in a separate analysis using 48-h electrocardiography monitoring of 1,193 participants in the ARIC cohort (adjusted OR 0.49, 95% CI 0.24–0.99)[21]. Examining a large sample of Medicare beneficiaries with implanted devices (pacemaker, cardioverter–defibrillator or loop recorder) in the USA from 2009 to 2015 identified a higher incidence of AF in white individuals (17.6 per 100 person-years, 95% CI 17.4–17.9) than in Black individuals (12.2 per 100 person-years, 95% CI 11.5–13.1)[22]. Similarly, in an analysis of the MESA study[23], a diverse, community-based sample of participants across the USA, white participants had a higher incidence of hospitalization for AF (adjusted incidence rate (IR) 11.23, 95% CI 9.82–12.84) than Hispanic (IR 6.07, 95% CI 4.71–7.84), Chinese (IR 3.94, 95% CI 2.54–6.11) or Black (IR 5.77, 95% CI 4.75–7.02) participants.

The higher prevalence of risk factors for AF in racial/ethnic groups under-represented in the clinical literature (such as Black, Hispanic or American Indian/Alaska Native individuals) but decreased observed prevalence of AF compared with white American individuals in the USA has previously been termed a paradox[24]. Researchers have assessed whether genetic factors (for example, European ancestry)[25] or structural cardiac factors, such as increased atrial ectopy in white individuals[26], might explain the differences in AF across racial and ethnic groups, although neither factor seems to fully explain this racially based variation. Other studies have examined social factors as the driver of these differences. In the REGARDS study[27], a US observational study of >30,000 Black American and white American participants, the likelihood of Black participants being aware of having AF was one -third of that of white participants (OR 0.32, 95% CI 0.20–0.52). An analysis of the MESA study[28] published in 2020 found similar rates of AF incidence across all racial and ethnic groups with the use of 14-day ambulatory continuous rhythm monitoring to detect AF instead of clinical detection. This finding suggests that differential clinical recognition of AF by providers might partly explain the racial/ethnic differences observed in AF incidence rather than true biological or genetic differences between racial/ethnic groups.

The aetiology of the paradox in the observed associations between race/ethnicity and AF is complex and incompletely understood. A partial explanation for the lower incidence and prevalence of AF in Black, Hispanic or American Indian/Alaska Native individuals in the USA than in white individuals is limited ascertainment owing to structural racism and decreased access to general and specialty health care among racial/ethnic groups under-represented in medicine. Nevertheless, with few exceptions, adequately powered studies have shown a higher incidence and prevalence of AF in white individuals than among individuals of other races/ethnicities in the USA[26–28]. Other possible explanations include varying rates of premature death by race/ethnicity that result in differential exposure to AF-related risk factors and therefore incidence of AF, a condition consistently associated with old age[1]. Furthermore, although traditional clinical risk factors for AF, such as hypertension, diabetes and obesity, are known to be more common in racial/ethnic groups under-represented in medicine, social factors that protect against AF might be present in these racial/ethnic groups, and further study of this possibility is warranted.

Race, ethnicity and AF management.

For decades, the cornerstone of AF management has been oral anticoagulation, which has been shown to reduce the risk of stroke by up to 70% in patients with AF[29]. Despite the clear benefits of stroke prevention with anticoagulant therapy, using either warfarin or direct oral anticoagulants (DOACs), research has demonstrated racial/ethnic inequities in the initiation, adherence and quality of this therapy[30–35].

Before 2010, warfarin was the only anticoagulant therapy available for the prevention of ischaemic stroke in individuals with AF, and several studies showed racial inequities in the use of this drug. An analysis of a large, hospital-based registry of patients with AF and heart failure in the USA showed that Black patients hospitalized with heart failure were less likely to be prescribed guideline-based warfarin therapy at discharge than white patients (OR 0.76, 95% CI 0.69–0.85)[36]. A retrospective cohort analysis of 98,053 patients in the US Veterans Health Administration demonstrated that white patients with AF receiving warfarin had a higher percentage of time in the therapeutic range than Black patients (62.3% versus 55.8%; $P < 0.001$)[32]. This racial difference in time in the therapeutic range was confirmed in a larger Veterans Health Administration analysis that demonstrated that time in the therapeutic range was higher in white individuals (0.57 ± 0.21) than in Black individuals (0.49 ± 0.23; $P < 0.001$) during their first year of receiving warfarin therapy[37]. These racial differences in time in the therapeutic range were sustained in the long term[37].

Few analyses have examined racial and ethnic differences in the initiation of DOAC therapy, but those studies that have point towards similar racial/ethnic disparities to those found with warfarin therapy[10,11]. DOACs, which were approved for stroke prevention in AF in 2008 by the EMA and in 2010 by the FDA, have demonstrated improved safety, effectiveness and treatment adherence compared with warfarin, but inequities exist in their use[38–40]. In the second cohort of the ORBIT-AF II, a retrospective US-wide registry of patients with AF from 2013 to 2016, Black individuals with AF had lower rates of DOAC initiation than white individuals, even after adjusting for clinical and socioeconomic factors (OR 0.73, 95% CI 0.55–0.95)[10]. Racial inequities in DOAC prescription were further confirmed in an analysis of >40,000 medically insured patients with AF aged 65 years in the USA, showing that DOAC therapy was less likely to be initiated in Black patients than in white patients (adjusted OR 0.75, 95% CI 0.66–0.85)[11]. Notably, even as DOAC use has increased over time and overall warfarin use is trending down, data suggest that compared with white patients, Black patients are more likely to be prescribed warfarin than more contemporary DOACs[41]. For example, a large analysis of patients with ischaemic stroke in the Florida Puerto Rico AF Stroke Study[41] showed that Black patients with AF were more likely than white patients to be discharged from the hospital with a prescription of warfarin therapy (OR 1.22, 95% CI 1.07–1.40).

Several AF cohort, registry and insurance claims database studies have similarly confirmed that Black patients are less likely to have adequate anticoagulation than white patients[10,30,37,42,43]. Additionally, researchers observed that among US Medicare beneficiaries, Black patients with AF were more likely to discontinue anticoagulation within 1 year of diagnosis than white patients (OR 1.45, 95% CI 1.25–1.72)[11]. A 2019 analysis of a national, hospital-based registry of patients with AF in the USA found that Hispanic

patients (90.2%) were less likely than white patients (93.7%) or Black patients (94.3%) to be discharged with a prescription for any anticoagulant ($P < 0.01$)[44]. Finally, a 2020 analysis of the PINNACLE registry, the largest cardiovascular outpatient registry in the USA, determined that American Indian and Alaska Native individuals were significantly less likely to be treated with anticoagulation than individuals of other races/ethnicities (OR 0.84, 95% CI 0.77–0.93)[45].

Together with disparities in oral anticoagulant therapy, racial differences have been observed for cardiac rhythm-control strategies. In a longitudinal US-based AF registry, white patients were more likely to receive antiarrhythmic medications or to undergo interventional procedures, such as cardioversion and catheter ablation, than Black patients[43,46]. Potential reasons for the treatment inequities include health-care provider bias, structural racism and limited access to health care. Furthermore, Black, Hispanic or American Indian/Alaska Native individuals have been poorly represented in US and international clinical trials and observational studies for AF, particularly in interventional studies[47]. Figure 3 summarizes the proportion of individuals of white and racial/ethnic groups under-represented in medicine in major AF clinical trials conducted globally. The poor enrolment rates of individuals of racial/ethnic groups under-represented in medicine limits the generalizability of trial findings and suggests selection biases in clinical trial development and recruitment.

Race, ethnicity and AF outcomes.

Underdiagnosis of AF as well as lower receipt of guideline-based therapies might contribute to observed differences in AF outcomes according to race. Previous research has demonstrated that Black patients with AF have higher rates of ischaemic stroke and cardiovascular morbidity, including myocardial infarction and heart failure, than white patients[12,14,48]. An analysis of the ARIC study concluded that Black participants with AF had double the incidence rates of stroke (21.4 versus 10.2 per 1,000 person-years; $P < 0.01$) and death (106.0 versus 55.9 per 1,000 person-years; $P < 0.01$) than white participants[12]. Disparities in stroke risk and mortality have also been described in Hispanic Americans with AF, including in a study of a national US registry of 24,000 participants that found 5.2 (95% CI 4.6–5.8) stroke cases per 100 person-years for white Americans, 12.2 (95% CI 8.0–18.5) for Black Americans and 10.6 (95% CI 6.0–18.7) for Hispanic Americans[49]. The racial and ethnic differences in the risk of ischaemic stroke in patients with AF served as the impetus for researchers to develop a refined CHA_2DS_2-VASc stroke risk score that added an additional point for Black race and reported significantly improved stroke prediction compared with the previous score[50]. Nevertheless, it has been argued that adding a point to capture the social construct of race without a known biological association to the outcome of interest cannot be heralded as the solution to addressing inequities in AF[51,52]. Instead, suggesting that Black race is an independent risk factor for stroke diminishes the contribution of centuries of structural racism or historical, cultural, institutional and interpersonal discrimination, neighbourhood segregation and underinsurance experienced by Black, Hispanic and American Indian/Alaska Native individuals in the USA, which have led to persistent health inequities[53,54].

Financial resources

Individual-level and household-level income constitute robust social determinants of health[55]. High income and wealth are associated with improved health-care access, provider decision-making[56,57] and clinical outcomes in patients with AF[58–61]. Conversely, lower income at both the individual and household levels has been related to higher rates of cardiovascular risk factors, adverse cardiac events and death in patients with AF[62,63]. We summarize in the next sections the associations between wealth and improved health-care access, treatment and outcomes in patients with AF.

Financial resources and AF incidence.

Longitudinal cohort studies have found that AF incidence is higher with worse socioeconomic position, as measured by income, educational status and employment status[20,64,65]. In a large, community-based, observational cohort study in the USA, AF incidence was higher among unemployed individuals than in those who were employed (OR 1.73, 95% CI 1.15–2.58) after adjusting for sociodemographic and economic factors[64]. Similarly, in the ARIC study, AF incidence was higher among participants with lower house hold income than in participants with higher house hold income (HR 1.45, 95% CI 1.27–1.67)[65]. In a New York City-based cohort study of 4,556 individuals, higher socioeconomic status, a variable that included neighbourhood-level income, was associated with a borderline, although not significantly, lower risk of AF (HR 0.99, 95% CI, 0.98–1.00)[66]. By contrast, a nationwide analysis from a longitudinal, community-based study in Sweden demonstrated that lower socioeconomic status was associated with a decreased incidence of AF (HR 0.79, 95% CI 0.77–0.81) and showed no association between neighbourhood socioeconomic deprivation and AF incidence (HR 0.98, 95% CI 0.95–1.01)[67]. Finally, a multi-cohort study of participants from Finland, Sweden and the UK who did not have AF found that those with longer working hours had a 1.4-fold increased risk of AF compared with those working standard hours (HR 1.42, 95% CI 1.13–1.80)[68].

Financial resources and AF management.

Oral anticoagulation remains under-prescribed globally for the prevention of stroke in AF, particularly in low-income countries[62]. Just as patient-level clinical factors and provider-level knowledge and comfort can influence anticoagulant prescribing patterns, so too can the patients' financial status. For example, among patients with AF in Sweden, higher socioeconomic status was associated with an increased likelihood of DOAC prescription rather than warfarin prescription in those in the highest-income quartile compared with those in the lowest-income quartile (OR 1.23, 95% CI 1.16–1.31)[69]. In addition, a Canadian study demonstrated that high neighbourhood income was associated with higher rates of DOAC prescription than warfarin prescription (OR 1.50, 95% CI 1.33–1.69)[56]. The same study showed that the addition of a DOAC to the Canadian drug formulary in 2012 led to the disappearance of this income-related prescribing disparity (OR 0.93, 95% CI 0.82–1.05)[56]. A retrospective study in Scotland of patients with AF who survived a stroke found that residing in neighbourhoods with higher socioeconomic deprivation was associated with a lack of prescription of oral anticoagulation (OR 0.59, 95% CI 0.57–0.76)[70]. A US-based insurance claims study of 35,000 individuals with newly diagnosed AF found

that individuals who were eligible for Medicaid insurance had a higher likelihood of discontinuation of anticoagulant therapy within 1 year of initiation than those not eligible for Medicaid (OR 1.94, 95% CI 1.38–2.70)[71].

In addition to preventing thromboembolic events, guidelines for the treatment of AF include managing comorbid conditions and achieving rate and rhythm control[72]. For patients who have medication-resistant AF or have intolerance to AF medications, treatment of AF via catheter-based ablation can reduce symptoms and improve quality of life[72,73]. Nonetheless, data show disparities in ablation referral depending on the economic status of the patient. A study of >16,000 patients in the USA admitted for AF catheter ablation revealed that recipients of ablation more often had private insurance (HR 1.17, 95% CI 1.11–1.22) and higher household incomes (HR 1.21, 95% CI 1.16–1.27, for the highest-income versus the lowest-income quartile) than non-recipients of ablation[57]. Data on the effects of socioeconomic status on receipt of other non-pharmacological AF therapies, such as percutaneous or surgical closure of the left atrial appendage, are limited and these effects require further investigation. Most of the available trials on these catheter-based or surgical therapies for AF do not specify participant income level or insurance status, limiting the generalizability of trial findings to economically diverse populations. The inclusion of social risk factors in AF clinical trials and registries has so far been limited and marks an important area for future study.

Financial resources and AF outcomes.

Individuals with AF can present with a range of symptoms secondary to differing patterns of arrhythmia, disease aetiology and comorbid conditions. The most debilitating of these symptoms is stroke, which studies have demonstrated to be more common in individuals with AF and low income. In a Canadian study of 166,742 individuals with AF aged 65 years, the patients in the lowest – Income quintile had an increased risk of hospitalization for stroke (HR 1.18, 95% CI 1.12–1.23) and fatal haemorrhage (HR 1.28, 95% CI 1.11–1.48) compared with those in the highest-income quintile[61]. A large Danish study also found that individuals with AF with higher socioeconomic status had lower all-cause mortality than those of lower socioeconomic status (HR 0.64, 95% CI 0.61–0.68), after adjusting for stroke risk and anticoagulant use[74]. This finding was supported by a single-centre, retrospective study in the USA that demonstrated that individuals in the lowest quartile of socioeconomic status had significantly higher mortality than those in the highest quartile (OR 1.3, 95% CI 1.1–1.5)[75]. Although a large insurance claims database study of >300,000 individuals with AF from the USA did not find a significant association between the risk of stroke and the patient income level, the study revealed a graded, inverse association between income level and the rates of AF-related hospitalization[58]. Individuals with AF who were in the lowest-income quintile had a higher risk of hospital admission for heart failure (HR 1.17, 95% CI 1.05–1.30) and myocardial infarction (HR 1.18, 95% CI 0.98–1.41) than patients with AF in the highest-income quintile[58].

AF can adversely affect quality of life, a main patient-reported outcome of AF. In a retrospective analysis of data from a large, US-based regional health-care system, individuals in the lowest-income quartile reported poorer health-related quality of life, as

measured by the Atrial Fibrillation Effect on Quality-of-life score, than those in the highest-income quartile (68.2 ± 21.4 for income less than US $20,000 versus 81.9 ± 17.0 for income more than $100,000; $P = 0.04$)[60]. This study also found that individuals in the lower-income category were significantly more likely to report poorer mental health, as measured by the 12-item Short Form Survey.

Rurality and neighbourhood factors

Rurality and AF.

A growing body of literature demonstrates differences in cardiovascular health and health outcomes between individuals residing in rural settings and those residing in urban settings[76–78]. Several factors contribute to poorer health outcomes in rural communities, including an increased burden of AF risk factors, such as old age, tobacco use, physical inactivity, diabetes mellitus, obesity and hypertension, as well as decreased access to health-care services[79]. For example, in the USA, individuals living in rural areas were more likely to smoke and were less likely to quit smoking than their urban counterparts[80,81]. In addition, data from a large, US-based cardiology practice registry revealed that individuals residing in rural areas were less likely to receive advice to quit smoking than individuals living in urban areas (OR 0.92, 95% CI 0.88–0.95; $P < 0.001$)[82]. These risk factors might result in a higher incidence and lower awareness of having AF in individuals living in rural areas[83].

Individuals residing in rural communities also more frequently have social factors that can have deleterious effects on cardiovascular health, including lower levels of income, education, food security and employment[76]. When considering education, the ARIC study found that AF incidence was higher in individuals with lower incomes and educational levels, independently of rurality[20]. Of interest, when examining the lifetime risk of AF in this study, the opposite pattern was observed, with a higher lifetime risk of AF with higher education and income levels[20]. Similar patterns were observed in a nationwide study from Denmark, in which men (HR 0.85, 95% CI 0.76–0.96) and women (HR 0.62, 95% CI 0.50–0.77) in the highest-education group had a lower incidence of AF than those in the lowest-education group[84].

Compared with urban residents, rural residents have multiple factors related to health-care delivery that impede access to timely, high-quality care, including transportation barriers, further driving distances to health-care services, lower-volume health-care facilities, increased hospital closings, higher rates of uninsurance or underinsurance, physician and nursing shortages, and limited access to clinical specialists[76]. When AF care is available in rural areas, it can be of limited quality[69]. In a nationwide Swedish study of patients with AF, researchers found that patients residing in rural areas were half as likely to be initiated on DOAC therapy than those in urban areas (OR 0.48, 95% CI 0.45–0.51)[69]. Furthermore, a national study of Canadian primary care practices found a higher likelihood of inappropriate DOAC dosing for AF in rural primary care practices than in urban primary care clinics (OR 2.1, 95% CI 1.7–2.6)[85].

Studies from some, but not all, countries have demonstrated that patients with AF residing in rural areas have increased risks of AF complications compared with their urban

counterparts. An analysis of a 2012–2014 US inpatient registry, in which nearly 60 million individuals (20% of the overall study population) resided in rural neighbourhoods, revealed that patients with AF admitted to rural hospitals had a higher risk of death than those admitted to urban hospitals (OR 1.17, 95% CI 1.04–1.32)[77]. By contrast, in a Canadian study of >25,000 adults with AF, clinical outcomes were similar between patients residing in rural and those residing in urban areas: 7.8% of patients in both groups died, with a similar rate of stroke or systemic embolism in patients residing in rural (3.2%) versus urban (2.8%) areas (OR 0.92, 95% CI 0.77–1.11)[78].

Despite the available data, the interventions that might attenuate the observed rural disparities in AF incidence and treatment remain unclear. A systematic review of interventions to improve cardiovascular disease management in individuals residing in rural areas found substantial variability in approaches (organizational, educational and telehealth), heterogeneous results and unclear improvements in health outcomes and mortality[86]. Similarly, major research gaps remain about effective strategies to increase disease awareness, treatment adherence and outcomes in individuals with AF residing in rural areas. One potential strategy to improve outcomes in rural settings is the use of clinical decision support tools. Whereas previous studies have examined the role of these tools in improving treatment access, including in patients with AF[87,88], a cluster-randomized controlled trial published in 2020 examining the use of computerized clinical decision support tools for the management of AF in rural versus urban settings did not show improved outcomes or safety compared with usual care[89].

Neighbourhood factors and AF.

The literature examining the relationship between neighbourhood factors and health is highly complex and heterogeneous; studies have tended to be observational and to have methodological challenges[90,91]. In addition, whether adjusting for coexisting factors, such as income and education level, accounts for confounders or over-adjusts for potential mediators is controversial. Nonetheless, neighbourhood socioeconomic level has been associated with differences in AF incidence, management and outcomes. Neighbourhood socioeconomic deprivation can result in poorer access to health care and sustaining resources, such as healthy food and safe spaces to exercise, resulting in poor health. One example is a US study of nearly 250,000 Medicare beneficiaries, in which neighbourhood greenness had a protective association with the risk of AF, but the association was not significant after accounting for cardiovascular disease risk factors (OR 0.94, 95% CI 0.87–1.00)[92]. A 2015 Swedish study found that individuals with AF residing in neighbourhoods of high socioeconomic status were more likely to be prescribed oral anticoagulation than those residing in neighbourhoods of low socioeconomic status[93]. Another Swedish study showed that in adjusted analyses, individuals with AF living in neighbourhoods of low socioeconomic status had a higher risk of death (HR 1.49, 95% CI 1.13–1.96)[94].

In the USA, individuals residing in counties with lower income levels and higher proportions of under-represented racial and ethnic groups are exposed to higher levels of environmental pollutants, with the associated lower life expectancy, compared with individuals residing in counties with higher income levels[95,96]. Studies of cohorts, regions and countries support

associations between air pollution and incident AF[97–99]. In a study of >5 million residents in Ontario, Canada, high levels of multiple air pollutants were significantly associated with an increased risk of new-onset AF, including fine particulate matter of 2.5 μm in diameter (PM$_{2.5}$; HR 1.03, 95% CI 1.01–1.04 per interquartile range increment), nitrogen dioxide (HR 1.02, 95% CI 1.01–1.03) and ozone (HR 1.01, 95% CI 1.00–1.02)[98]. Analogously, in a Danish cohort study, exposure to road traffic noise was associated with an adjusted 6% higher risk of incident AF (adjusted IR 1.06, 95% CI 1.00–1.12) for every 10-dB increase in road traffic noise[100]. Another study of 31,414 adults with AF in a large health-care system in a US region with high industrial activity demonstrated an association between the highest quartile of PM$_{2.5}$ levels and the risk of ischaemic stroke (HR 1.20, 95% CI 1.00–1.44) relative to the lowest quartile[101]. Although at an individual level, the relative risks associated with air pollution exposure are small, given the ubiquitous and disparate exposures at the population level, these risks are consequential.

Health literacy

Health literacy is the "capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions"[102]. Low health literacy is widely prevalent worldwide and is adversely associated with heterogeneous risk factors, diseases and health outcomes, in addition to greater health-care utilization and costs[103]. Limited English proficiency, a correlate of health literacy in English-speaking countries, is designated by individuals having a primary language other than English and challenges with English reading, writing or verbally communicating[104]. For example, approximately 36% of the US adult population is estimated to have limited health literacy and 8% to have limited English proficiency[105]. In 2018, 49% of foreign-born adults in the UK reported speaking a language other than English as their primary language[106]. AF is a complex condition that demands ascertainment of the condition, education about the disease, symptom recognition, treatment adherence and access to specialty health care for potentially complex treatments and medications. Therefore, limited health literacy and/or limited local language proficiency (LLLP) are likely to influence many of the individuals' experiences with AF.

Health literacy, language proficiency and AF awareness.

Low health literacy is associated with reduced knowledge of AF, its treatment and related outcomes. Research indicates that individuals with limited health literacy have decreased understanding of AF and the importance of anticoagulation for stroke prevention[107,108]. A study of an ethnically diverse US cohort of 12,500 patients with AF from 2006 to 2009 reported that patients with inadequate health literacy were less likely to be aware of their AF diagnosis than patients with adequate health literacy (prevalence ratio 0.96, 95% CI 0.94–0.98)[109]. A study of an ethnically and linguistically diverse sample of patients in the USA who were taking warfarin from 2002 to 2003 found that nearly 40% of participants had inaccurate perceptions of stroke and only 33% of participants were able to describe a symptom or sign of stroke[110]. Although, to our knowledge, health literacy and LLLP have not been included as factors in AF clinical trials or registry-based studies, their importance is underscored by an international survey of physicians in which 46% of respondents considered their patients to be unable to explain AF adequately[111].

Health literacy, language proficiency and AF treatment.

AF requires self-management of symptom recognition and adherence to medications. In individuals taking warfarin therapy, health literacy has been related to less time in the therapeutic range, even when adjusting for demographic factors[112,113]. An Australian study identified that individuals with poor anticoagulation control were more likely to have limited health literacy (OR 4.0, 95% CI 2.1–7.4) than referents with superior anticoagulation control, as defined by warfarin monitoring[112]. Although few studies have examined the effect of LLLP on medication adherence, a single-centre, retrospective study of 3,770 patients with AF in the USA further identified that individuals with LLLP were less likely to maintain time in the therapeutic range than those with local language proficiency, even after adjustment for sociodemographic and clinical factors[113].

Social determinants of health and social factors intersect with health literacy and local language proficiency through multiple pathways[5,114]. The shared decision-making articulated by AF management guidelines for the initiation of anticoagulation can be challenged by limited health literacy and local language proficiency[115]. Low health literacy and local language proficiency are associated with decreased patient-centred communication and, in turn, diminished shared decision-making[116]. Despite the increased recognition of the importance of these social determinants to the patient experience of AF, the relationship between AF, low health literacy or local language proficiency, and shared decision-making requires further study and addition to future AF clinical guidelines[117].

Social support and social networks

Social support and AF.

Little investigation has been performed on the association between social support or social isolation and cardiovascular disease, specifically AF[5]. We include these factors in our Review as a knowledge frontier that merits further exploration. Multiple observations suggest the relevance and influence of social isolation on AF incidence, including by being associated with common risk factors for AF, such as obesity, tobacco use and alcohol consumption[118]. However, a 2020 analysis of 11,445 participants of the ARIC study who were free from AF at baseline found no significant association between social ties and AF incidence[119].

Social integration is associated with a lower incidence of cardiovascular disease and mortality[120]. A study in the USA found that women without a spouse or a partner had increased cardiovascular mortality than married or partnered women[120]. Strong social integration seems to be beneficial to health even in individuals with poor socioeconomic and educational status and in older people[121–123]. Despite the plausibility of a relationship between social isolation and AF incidence, this concept has not been studied. The mechanisms for this potential relationship include the described role of stress on the development of cardiovascular diseases such as AF as well as the specific biological pathways through which stress promotes disease progression[120,124,125] (Fig. 4).

Social connectedness and AF.

In an era of broad Internet availability, mobile devices and diverse social media platforms, digital health applications (apps) provide an avenue to increase social engagement. Nevertheless, a digital divide exists in which certain populations, including under-represented racial and ethnic groups, those with low income and education level, rural residents and older adults, have less access to advanced mobile technology[126]. Furthermore, for those who do have access, many digital apps demand high readability, as evidenced by a review of mobile apps for AF directed at non–health-care providers that determined that these apps had a readability score of 12.1 ± 2.6 grade level (that is, fairly difficult to read)[127,128]. The researchers further found that all English language apps that included patient education text were written above the recommended 5th–6th grade reading level, that 49% of apps were written above the 12th grade reading level and that 7% of apps were written at a college-grade reading level.

Whether digital health apps can improve social support in patients with AF is unknown. Nevertheless, to date, nearly 200 English and non-English language mobile apps that are related to AF are available in the two leading digital app marketplaces, the Apple App Store and Google Play Store[127]. Few apps provide patient-level social support through online communities or groups. Beyond the app landscape, a study published in 2019 of 816 adults with AF aged 65 years found that 40% reported interest in an online AF patient community[129]. As these and other data show, opportunities exist to broaden the role of digital apps for AF care to those individuals with traditionally limited access, such as older adults at high risk of social isolation.

Future directions

In this Review, we highlight several important pathways through which social determinants influence AF incidence and outcomes. We also reveal opportunities for further study within each social determinant described, as we summarize below, including the crucial need for clinical trials, registries and cohort studies of AF to include, measure, quantify and report social determinants to improve the interpretation and increase the generalizability of the findings to broader populations (Fig. 5).

- Important areas for future study include a deeper understanding of race/ethnicity as a social construct, the interaction with other social determinants and the role that structural racism and provider implicit biases have in the patient experience of AF and in the provider management of AF.

- Factors such as access to safe neighbourhoods and healthy food, allostatic load, childhood adverse events, housing instability and homelessness, incarceration, immigration status and adverse working conditions are not fully examined in this Review given the paucity of literature describing associations between these factors and AF incidence and outcomes.

- Future studies need to examine how financial resources and health-care coverage, together with the intersection of these factors with other social determinants such

as race/ethnicity, education and rurality, impede the efficacy of AF prevention, treatment and associated quality of life.

- To address rural inequities in AF, studies into the implementation of mobile-health and telemedicine strategies should be adapted. Furthermore, a gap remains in the literature for several pertinent neighbourhood-level factors, including structural, demographic and environmental factors, that might influence AF treatment and outcomes.

- Multiple gaps are present in the study of health literacy, LLLP and AF, despite the importance of these concepts to medication adherence, health-care access, symptom recognition and adverse outcomes. Adaptation and testing of tools with demonstrated utility for chronic disease self-management are essential. Measurement of health literacy and local language proficiency as part of clinical trials, registries and community-based studies will facilitate assessing the role of risk factors in AF. Other areas that merit investigation include longitudinal, patient-centred educational interventions as well as the effect of language-concordant care (in which the patient and clinician speak the same language) on outcomes in individuals with AF and LLLP.

- Further exploration of potential protective factors for AF such as spirituality, social support and resilience is warranted. Additionally, little is known about the role that caregivers have in improving AF treatment rates and outcomes[130]. Furthermore, whether the longitudinal effects of social isolation and pathophysiological and/or psychological health influence AF outcomes requires attention and investigation.

- Future research should examine the mediating and intersectional influence of multiple social determinants on structurally disadvantaged populations with AF. Most fundamentally, effective policies and implementation strategies to eliminate the inequitable effect of social determinants of AF need to be researched.

Conclusions

Examining the social determinants of AF provides an opportunity to improve health in individuals with AF. Social determinants — race/ethnicity, financial resources, rurality and residential environment, language proficiency and health literacy, and social support — have a prominent role in the detection, evaluation, treatment and management of AF. Through describing the relevance and importance of integrating social determinants into the prevention, ascertainment, management and further research of AF, we envision a future of more equitable and high-quality care for patients with this increasingly common cardiac condition.

Competing interests

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Key points

- Atrial fibrillation is the most common cardiac rhythm disorder, affecting nearly 60 million adults worldwide, and is associated with substantial morbidity and mortality.

- Social determinants, such as race/ethnicity, financial resources, social support, rurality and residential environment, and health literacy, have crucial roles in the detection, evaluation, treatment and management of atrial fibrillation.

- Despite their fundamental importance, to date, critical evaluation of the social determinants of health in relation to atrial fibrillation has been limited.

- Collecting, studying and addressing social determinants of health provides an important opportunity to reduce the substantial social and economic burden of atrial fibrillation and its associated complications.

- Important areas for future research include an examination of the intersectional influence of multiple social determinants of health on disadvantaged populations with atrial fibrillation and implementation strategies to eliminate health-care inequities.

Box 1 |

US definitions of racial and ethnic groups[a]

- White: a person having origins in any of the original peoples of Europe, the Middle East or North Africa.

- Black or African American: a person having origins in any of the Black racial groups of Africa.

- Hispanic or Latino: a person of Cuban, Puerto Rican, Central or South American, or other Spanish culture or origin, regardless of race.

- American Indian or Alaska Native: a person having origins in any of the original peoples of North and South America (including Central America) and who maintains tribal affiliation or community attachment.

- Asian: a person having origins in any of the original peoples of the Far East, Southeast Asia or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand and Vietnam.

[a]As defined by the US Census Bureau, 2020.

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Readability score

A score indicating how difficult a text in english is to understand; it can be graded according to us school and higher education level: 5th grade (very easy; easily understood by students aged 11 years), 6th grade (easy; conversational english for consumers), 7th grade (fairly easy), 8th–9th grade (plain english; easily understood by students aged 13–15 years), 10th–12th grade (fairly difficult), College (difficult), College graduate (very difficult) and Professional (extremely difficult).

Allostatic load

The 'wear and tear' on the body that accumulates as an individual is exposed to repeated or chronic stress.
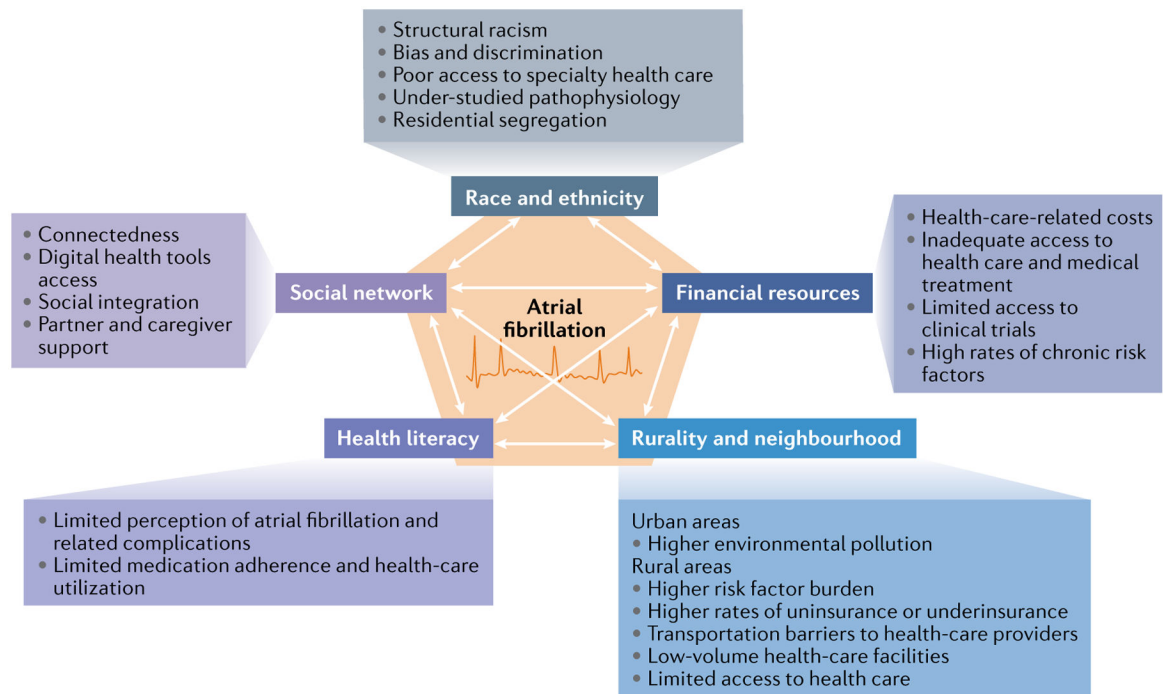
Fig. 1 |. Social determinants of atrial fibrillation.
The figure represents the broad, interconnected social determinants and the proposed mechanisms by which they might influence atrial fibrillation incidence, treatment and outcomes. These social determinants include race and ethnicity, financial resources, rurality and neighbourhood residence, health literacy and social networks.
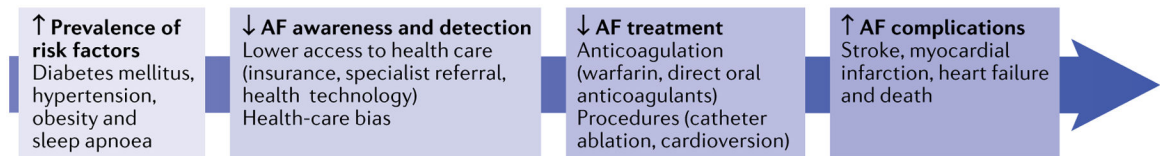
| ↑ **Prevalence of risk factors** Diabetes mellitus, hypertension, obesity and sleep apnoea | ↓ **AF awareness and detection** Lower access to health care (insurance, specialist referral, health technology) Health-care bias | ↓ **AF treatment** Anticoagulation (warfarin, direct oral anticoagulants) Procedures (catheter ablation, cardioversion) | ↑ **AF complications** Stroke, myocardial infarction, heart failure and death |

Fig. 2 |. Determinants of racial and ethnic inequities across the atrial fibrillation care continuum. The figure represents where inequities in racial and ethnic groups under-represented in medicine affect the continuum of atrial fibrillation (AF) development and management. These inequities include high prevalence of risk factors for AF, poor awareness and detection of AF, low access to AF treatment and a high prevalence of AF-related complications.
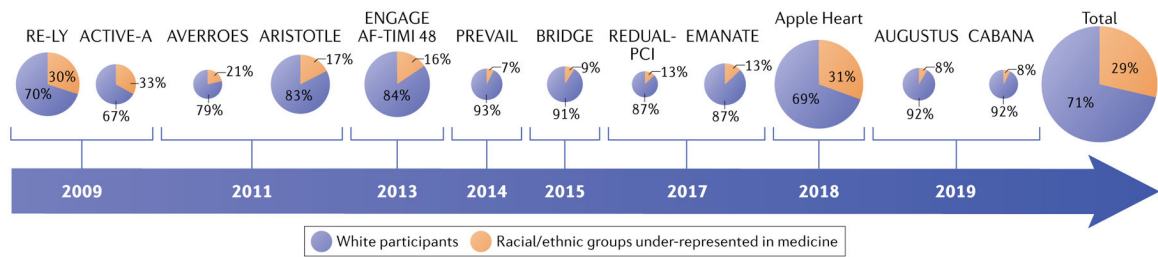
Fig. 3 |. Racial/ethnic representation in clinical trials and observational studies of atrial fibrillation.

Chart illustrating the proportion of white participants (blue) versus participants from racial and ethnic groups under-represented in medicine (orange) in clinical trials and observational studies of atrial fibrillation and anticoagulation conducted internationally between 2009 and 2019 (REFS[38,39,131–140]). The year of publication of the study is shown in the arrow. The sizes of the individual pie charts indicate the relative overall size of the trial or study, except for the total chart.
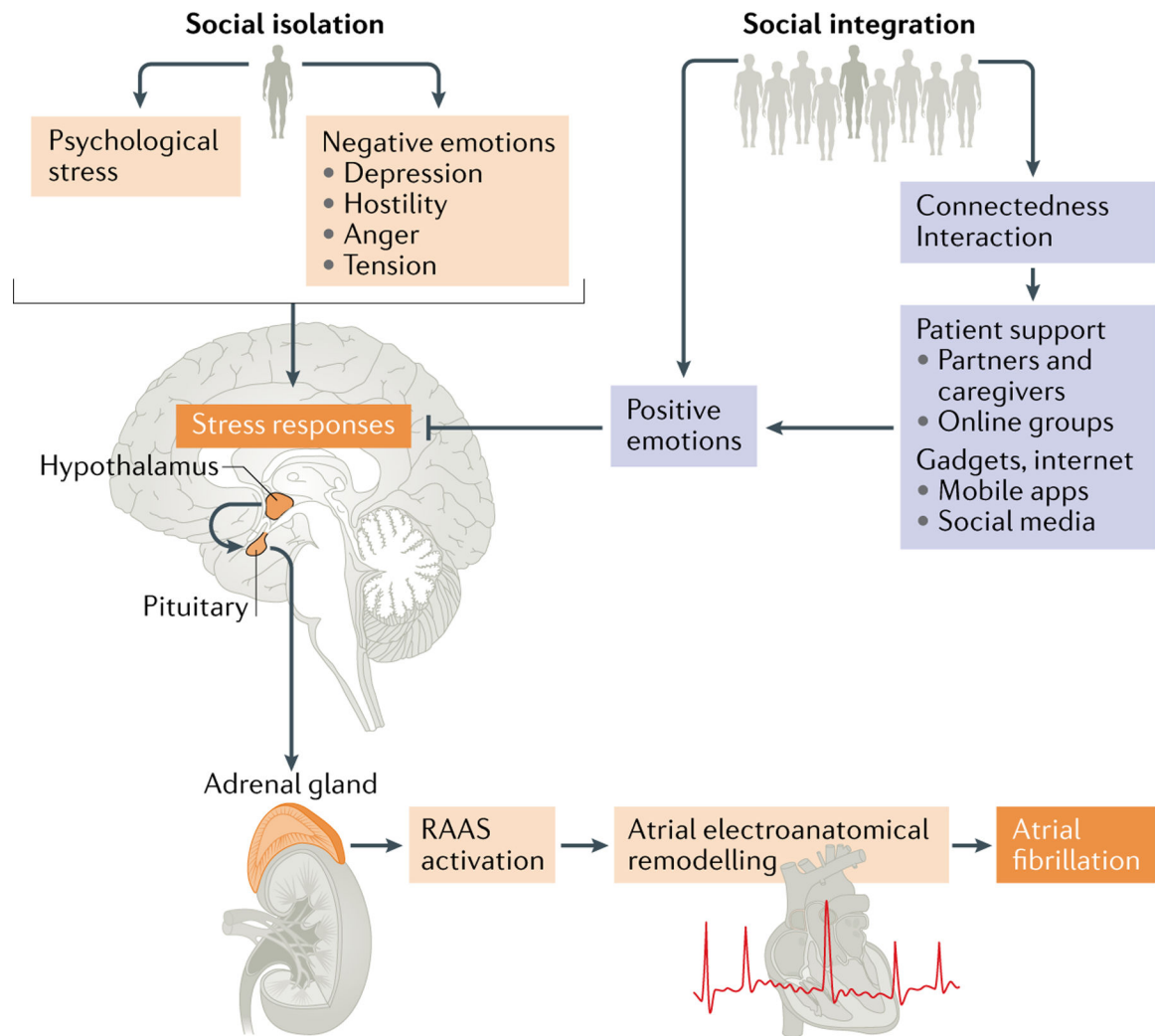
Fig. 4 |. Proposed framework for the role of social networks and social support in atrial fibrillation.

The figure illustrates the pathways through which social isolation and social integration might act to influence atrial fibrillation symptoms and outcomes. Psychological stress has a role in atrial fibrillation initiation through the activation of the autonomic nervous system, hypothalamus–pituitary–adrenal axis and the renin–angiotensin–aldosterone system (RAAS), which might contribute to atrial remodelling. The chain of reactions caused by stress could be attenuated by positive emotions, including those invoked by improved patient support and access to diverse social networks.
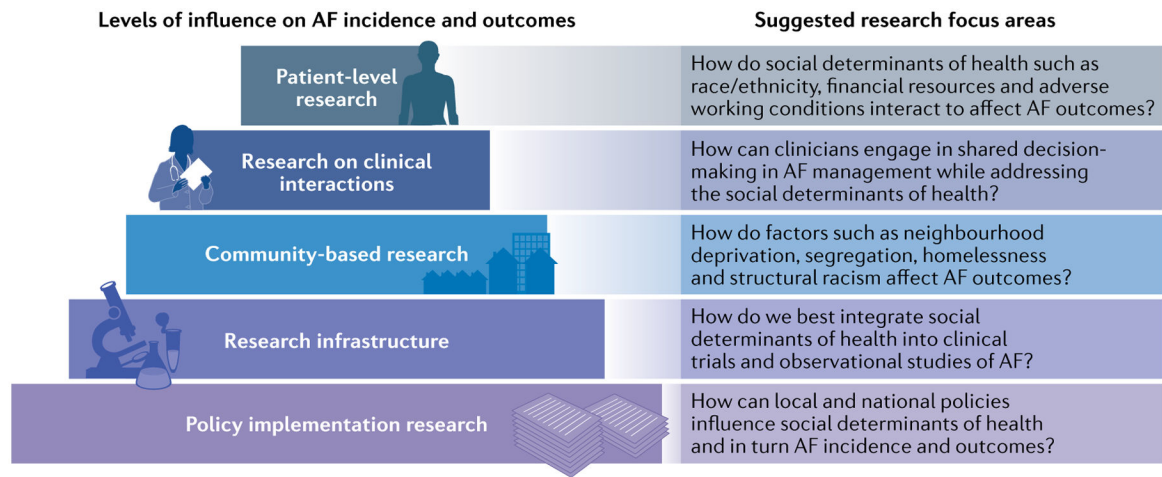
Levels of influence on AF incidence and outcomes   **Suggested research focus areas**

Patient-level research	How do social determinants of health such as race/ethnicity, financial resources and adverse working conditions interact to affect AF outcomes?
Research on clinical interactions	How can clinicians engage in shared decision-making in AF management while addressing the social determinants of health?
Community-based research	How do factors such as neighbourhood deprivation, segregation, homelessness and structural racism affect AF outcomes?
Research infrastructure	How do we best integrate social determinants of health into clinical trials and observational studies of AF?
Policy implementation research	How can local and national policies influence social determinants of health and in turn AF incidence and outcomes?

Fig. 5 |. Future directions for research on social determinants of atrial fibrillation.
The represented framework emphasizes the separate, yet overlapping, levels of research needed to understand how social determinants of health influence atrial fibrillation (AF) incidence, treatment and outcomes. The levels include: the intrapersonal, patient-level; interpersonal clinical interactions; community level; and broader infrastructure influences on the health of individuals and populations, including research infrastructure and policy implementation. The figure offers a systematic approach to future research as well as suggested focus areas.