the globe demand that no more of this blood is spilled.

Call it reproductive rights, human rights, reproductive justice, or just plain health care, safe accessible maternity care and safe accessible abortion are two sides of the same coin. Millions of women will require both in their lifetime. As a community of people who hold health and justice dear, we should fight with all our might to support and facilitate both.

I declare no competing interests

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An AI-ECG algorithm for atrial fibrillation risk: steps towards clinical implementation

We read with interest the Article by Zachi I Attia and colleagues[1] describing the use of artificial intelligence (AI) using a convolutional neural net for identification of patients at risk of atrial fibrillation from electrocardiograms (ECGs) taken during sinus rhythm.

Although their study is provocative, we were concerned about two methodological issues in their study design. First, the authors used an aggregated cohort for their model that included individuals who never developed atrial fibrillation, but had at least one ECG combined with those who had by definition at least two ECGs (one with atrial fibrillation and another ECG within 31 days). Furthermore, the authors only included the first ECG in their analysis of the group of individuals who never developed atrial fibrillation over a 24-year period. During such a long interval, subtle signal characteristics could have changed because of changes in ECG equipment models and settings. Hence, rather than detecting atrial fibrillation, their model might be detecting the individuals who are more likely to have multiple ECGs or recent ECGs. Second, the authors do not report basic demographic characteristics, such as age, sex, and race, with common ECG abnormalities, such as heart rate, Q waves, left ventricular hypertrophy, left atrial enlargement, PR interval, P wave amplitude, P wave duration, and P wave axis, for patients who were either positive or negative for atrial fibrillation. It would be informative to see these baseline patient characteristics. Such features are often automatically identified by existing algorithms and encoded automatically into searchable fields in many commercial ECG software packages. A control analysis using standard statistical methods that incorporated many of these features might have had similar performance characteristics and would certainly offer greater mechanistic insights than the current analysis.

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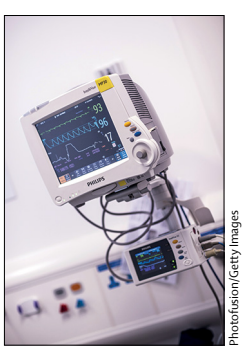
1 Attia ZI, Noseworthy PA, Lopez-Jimenez F, et al. An artificial intelligence-enabled ECG algorithm for the identification of patients with atrial fibrillation during sinus rhythm: a retrospective analysis of outcome prediction. *Lancet* 2019; **349:** 861–67.

Zachi I Attia and colleagues[1] show us that we live in a time in which there is more to computer observations than meets the eye. Machine-learning methods for detecting imminent atrial fibrillation on electrocardiograms (ECGs) with sinus rhythm are a valuable step forwards, especially for patients with embolic stroke of undetermined source. However, some methodological drawbacks—related to the selection of controls—hamper implementation of their presented algorithm in clinical practice.

The authors compared ECGs of patients with atrial fibrillation to those of relatively young controls who did not have atrial fibrillation during the 24-year study period. This approach led to selection of extremely healthy controls with ECGs that are very different from patients in the average transient ischaemic attack or stroke clinic.[2,3] Most patients with transient ischaemic attack and stroke are older than 70 years, often with some degree of heart disease and at high risk of developing (aetiologically unrelated) atrial fibrillation in subsequent years.[3,4] Consequently, these individuals' ECGs differ much less from those of patients with atrial fibrillation-related cardioembolic stroke than the control ECGs in Attia and colleagues' study, therefore probably inflating the diagnostic value of the artificial intelligence (AI) algorithm compared with real-life practice. This inflation can be avoided by age-matched density sampling—ie, calendar time matching of controls to cases, irrespective of later development of atrial fibrillation in the controls.[5]


Photofusion/Getty Images

The approach by Attia and colleagues offers exciting opportunities, but I believe that it is essential to train, or at least externally validate, such algorithms on target populations to avoid poor diagnostic performance, patient harm, and research waste in subsequent clinical trials.

I declare no competing interests.

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1 Attia ZI, Noseworthy PA, Lopez-Jimenez F, et al. An artificial intelligence-enabled ECG algorithm for the identification of patients with atrial fibrillation during sinus rhythm: a retrospective analysis of outcome prediction. *Lancet* 2019; **394:** 861–67.
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The idea of being able to predict incident atrial fibrillation from just a 12-lead electrocardiogram (ECG) with no demographic or clinical information in the Article by Zachi I Attia and colleagues[1] raised much interest at the meeting of the AF-SCREEN International Collaboration.[2]

A crucial issue that could limit the use and generalisability of the study comes from patient selection for atrial fibrillation prediction, in which patients with a sinus ECG in the 31 days before, or any time after, incident atrial fibrillation, were selected. Although 1698 (55·7%) of 3051 normal sinus rhythm ECGs were recorded within a week of the index atrial fibrillation ECG, multiple sinus ECGs were recorded in the 31 days before atrial fibrillation, according to figure 1.[1] This intensity of ECG testing would be quite unusual in the outpatient setting. The median time between the sinus and atrial fibrillation ECGs was 0 days (IQR −4 to 24), so a large number of ECGs used to predict atrial fibrillation were done on the same day as, or soon after, the index atrial fibrillation ECG. Therefore, these ECGs are likely to be after electrical, pharmacological, or spontaneous cardioversion for clinically detected atrial fibrillation, which could alter the ECG in ways detected by the artificial intelligence algorithm. Additionally, it is highly likely many individuals included were patients who had been admitted to hospital. Therefore, the results might be pertinent for prediction only in patients who had been hospitalised for heart failure, ischaemic chest pain, other acute medical conditions, cardiac or non-cardiac surgery, or clinically manifested atrial fibrillation requiring cardioversion. The Article provides none of this clinical information. If these assumptions are correct, it would have substantial implications on the generalisability of the results for screening in asymptomatic people or even in people after stroke, to predict future atrial fibrillation.

See Online for appendix

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1 Attia ZI, Noseworthy PA, Lopez-Jimenez F, et al. An artificial intelligence-enabled ECG algorithm for the identification of patients with atrial fibrillation during sinus rhythm: a retrospective analysis of outcome prediction. *Lancet* 2019; **394:** 861–67.
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Authors' reply

We thank our colleagues for their interest in our Article[1] about artificial intelligence (AI)-enabled electrocardiogram (ECG) to identify patients with atrial fibriliation. They have posed key questions about confounding of the model by potential differences in baseline characteristics and about generalisability.

We see measurable differences between groups that need to be acknowledged (appendix p 1), but in a sensitivity analysis stratifying by age and sex (appendix p 2) we observe consistent area under the curve values across a range of subgroups. This analysis is reassuring because it indicates that the ECG adds value in addition to chronological age and sex, which have been shown to have only modest performance for estimating the risk of atrial fibrillation.[2]

However, we chose not to take this analytical approach in our Article, instead seeking to address a risk stratification question. In previous work we showed that the ECG can predict age, sex, and low ejection fraction with high accuracy[3,4] and, as such, we see the ECG as a composite biomarker that might aggregate the electrocardiographic signature of various demographic features and comorbidities. By not matching cases and controls on age, sex, or other features, we capture ECG characteristics that are associated with atrial fibrillation risk among typical, unselected patients. This approach allows us to use a single ECG in isolation to assess risk of atrial fibrillation, leading to a tool that might be easier to adopt clinically. An AI-ECG algorithm that aggregates risk factors such as ECG-derived age, ECG-derived sex, electrocardiographic manifestations of overt heart disease, and presumably subtle signs of atrial cardiopathy detectable only by a convolutional neural network will provide a more nuanced assessment of risk.

The questions about generalisability are equally valid. We previously found that our low ejection fraction model worked equally well across ethnic and racial groups, but each model must be independently assessed. To address generalisability, we are doing several validation studies using existing external cohorts and are starting a prospective study to assess incident atrial fibrillation detected by an event monitoring patch in patients at high risk (NCT04208971). These ongoing studies will help us refine the model and determine whether it requires adaptation for different cohorts and how we can best use it for targeted atrial fibrillation screening, treatment