# SMART WATCHES IN EARLY DETECTION OF STROKE IN PATIENTS WITH CVD - A SYSTEMATIC REVIEW.

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**Abstract:**
**Background:**
Recently, smart devices have been employed for medical purposes, specifically to check for atrial fibrillation (AF), assess pulses and prevent stroke in patient with CVD. There is currently a paucity of information about how well these devices work diagnostically.
**Methodology:**
The current research conducted a literature search of articles that had been published between the years of 2012 and 2022 in PubMed, Medline, the Cochrane Library, the Web of Science, and other sources (Google Scholar, clinicaltrails.gov). We examined the main electronic databases. Due to the nature of the review, all kinds of studies were included, including descriptive studies, surveys, reviews, commentaries, and editorials. In the current research, the recommended methodology was employed to evaluate the risk of bias. The six distinct areas were addressed using the two-part tool. The studies' quality was assessed using the diagnostic accuracy study quality evaluation tool.
**Result:** Four thousand two hundred twenty six subjects participated in a total of 14 studies that evaluated diagnostic accuracy using smart watches. The overall sensitivity of 91.80% was found in the 14 studies and the average accuracy of the 96.11% was found in the 7 studies reports as well as the remaining 7 studies are not stated.
**Conclusion:** This review determined that smart watch technology currently has a high diagnostic accuracy for early detecting the stroke in patients with CVD as well as the cardiac arrhythmias.

**Keywords-** *Stroke, cardiovascular disease, smart watches*

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## BACKGROUND:

The World Health Report 2002 [1] predicted that by 2020, CVD would be the leading cause of death and impairment in India. In India, it is the primary cause of mortality, coming in first place among the top five. (Rural vs. urban, economically backward vs. developed states, males vs. women and all stages vs. middle age) [2]. By 2015, CVDs, which have grown at a 9.2 % annual rate since 2000, are anticipated to be the chronic ailment with the fastest rate of growth [3].

The leading cause of mortality worldwide is CVDs, which account for 17.9 million deaths annually. In 2019, it was determined that hypertension was the primary factor in 65.5% of instances of cardiovascular disease (CVD), followed by ischemic heart disease (11.4%), arrhythmias (6.5%), peripheral vascular disease (6.5%), and cerebrovascular disease or stroke (6.5%) (5.8%). Heart failure, rheumatic heart disease (3.5%), atrial fibrillation along with atrial flutter as well as rheumatic heart disease (2.3%) (1.1%), hypertensive heart disease, coronary heart disease or cardiopathy (1.08%), cardiomyopathies (0.53%), and fetal cardiac disease (0.7%) are among the most common types of cardiovascular disease [4], [5]. Such outcomes illustrate how important it is to support initiatives for treating and preventing hypertension in decreasing the prevalence of CVDs worldwide.

Heart and blood vessel damage from CVDs can result in strokes, coronary disease, rheumatic and autoimmune illnesses. Eighty percent of CVD-related deaths are caused by coronary heart disease along with stroke, and thirty-three percent of those deaths occur before the age of seventy [6]. In addition, poor eating habits that encourage obesity and overweight, such as an unbalanced diet and a high intake of salt, sugar, and fat, implicitly increase the risk of CVDs [7]. Increased workload, irregular sleeping patterns and an unhealthy lifestyle have all contributed to a decline in human health, particularly heart health [8]. According to the European Heart Journal [9]. CVD is the leading cause of death worldwide among people of all ages, accounting for more than 4 million deaths in Europe each year. However, due to rising healthcare costs, finding dependable and low-cost healthcare facilities has become increasingly difficult for ordinary people [10].

Avoiding early CVD-related detecting high-risk individuals and ensuring they receive the necessary care, to prevent deaths treatment. To provide CVD treatment, non-communicable diseases must be treated in all primary healthcare facilities. Everyone needs to receive treatment and counseling [7], [11].

AF is the most prevalent long-term heart rhythm disorder. Adults with arrhythmia, face a lifetime risk. It is present in 25% to 33% of individuals and is connected to death, dementia, stroke, and heart failure [12], [13]. The likelihood of stroke appears to be correlated with the intensity and length of AF. Therefore, a wearable consumer electronic gadget might offer a non-intrusive, economical long-term evaluation of the metrics [14].

Now that mobile devices and wearable sensors have been developed, it is feasible to monitor your health on a daily basis. The market for smart technology has reached over 450 million sales, and it is still expanding. These gadgets are now selling more than ever, with an annual growth rate of about 20% [13], [14]. The smart watch is one of these that have drawn a lot of attention because of its ability to function as a wristband-style continuous pulse measuring terminal. This device includes a photo plethysmograph (PPG), which is a photodetector that monitors blood volume changes in the microvasculature using infrared light-emitting diode optical sensors [15].

On the smart watch, pulse rate can be constantly and passively estimated using PPG. Each pulse signal gathered by PPG correlates to an R- wave on an electrocardiograph (ECG) [15].

If the R-wave in AF can be identified using PPG with high accuracy, it might be possible to identify AF based on pulse rate [16], [17]. A PPG-based algorithm for identifying AF would therefore be a strong substitute for the current (ECG)-based monitoring, which has drawbacks, especially in patients with asymptomatic paroxysmal AF [18], [19].

Early and prompt diagnosis is essential for a good prognosis of CVD and stroke, according to **Qureshi et al.'s 2012** analysis. Numerous cardiac-specific indicators were mentioned in this instance, including: myoglobin, B-type natriuretic peptide (BNP), Cardiac Troponin I (cTnI), C-reactive protein (CRP), Interleukins, and Interferons are a few other blood markers.

There are multiple methods of detecting and recognising the aforementioned biomarkers, including acoustic (CMOS Si chips), electrochemical (potentiometric, amperometric, and impedimetric transducers), optical sensors (colorimetric, fluorescence, luminescence, surface plasma resonance, fiber optics, bio-optrodes), magnetic-based biosensors, and other biomarkers. Furthermore, for the clinical investigation patients follow their routine cardiac checkup using traditional methods such as echocardiograms, computerized tomography scans (CT scans), magnetic resonance imaging (MRI) and nuclear myocardial perfusion scans were taken. These procedures necessitate the use of costly hardware and software and should be handled by hospital professionals. Furthermore, such clinical approaches are time-consuming, labor-intensive and patient-centered [20]. For regular examinations, given the gravity of the situation of the patients must go to the hospital, there has been a rise in the number of those who want to have a low-cost, long-term cardiac health monitoring system.

In this review, we examine wearable technologies used to track biological factors related to CVD that are both commercial and noncommercial. According to the results of this research, commercial wearables frequently include smart wristbands, patches, and watches. These devices are used to measure things like blood oxygen saturation, heart rate, and electrocardiogram data.

**MAIN TEXT:**

**Methodology:**

**Overview:**
The study was conducted and reported in compliance with the PRISMA (Preferred reporting items for systematic reviews) statement.

**Search Strategy:**
Using the databases from Google Scholar, Embase, MEDLINE, PubMed, Scopus, Web of Science, and the Cochrane Library, a comprehensive literature search was carried out. All articles published up to 2022 were considered for this study, covering CVD, stroke detection associated with CVD, irregular pulses or atrial fibrillation, wearable electronic devices, smartwatches, wristbands, diagnosis alongside detection, and using the appropriate MeSH (Medical Subject Heading) terms and free text searches for all fields. A number of search keywords were used in the Cochrane library, including arrhythmia, cardiac or atrial fibrillation, irregular heartbeat, wearable devices, smartwatches, and wearable electronic devices. (Fig 1)

**Inclusion and Exclusion Criteria**
**Inclusion criteria:**
There are a number of studies that have been published or translated into English that show that smartwatches can detect strokes, and studies that also show diagnostic sensitivity and accuracy.

**Exclusion criteria:**
research without original data (such as review articles or letters); Studies without complete text; Studies older than 20 years.

**Study Quality assessment:**
The quality assessment of diagnostic accuracy investigations tool was used to assess the risk of bias in the comprised studies. This assessment allowed for a comprehensive assessment of the quality and risk of bias of the studies, allowing for a more confident interpretation of the results. Each domain's bias risk was categorized as low, high, or uncertain.

**Statistical analysis:**
The tool RevMan 5.4.1 was used to conduct the current research in accordance with the suggested methodology for determining the risk of bias in studies included in Cochrane Reviews (Higgins 2011).

**RESULT:**
**Study description:**
Initial searches for the current systematic review turned up 249 papers; the first 213 duplicate publications were eliminated. 204 additional items were screened and removed because some parameters were missing in search articles and also some articles were incomplete and irrelevant with present study. 103 full articles were assessed for the study. After performing complete screening and analyzed data a total 14 studies were included in this present systematic review. (Fig 1) The articles ranged in date from 2012 to 2022.

Our analysis includes 14 studies, including 9 prospective studies, 2 observational studies, 1 pilot cohort study, 1 multicenter prospective case control and 1 multinational, cohort study. The overall sensitivity of 91.80% was found in 14 studies [7], [21], [22], [23], [24], [25], [26], [27], [28], [29], [30], [31], [32] and [33]. The average accuracy was about 96.11% was found in the 7 studies [21], [22], [23], [28], [29], [30], [32] descriptions as well as the remaining 7 studies were not stated. (Table 1)

**Quality assessment:**
The risk of bias for RCTs was assessed using the Cochrane cooperation instrument and the RevMan program. The risk assessment categories were rated as high, uncertain, or low risk depending on the presence of selection bias (random sequence generation and allocation concealment), performance bias (blinding), detection bias (assessor blinding), attrition bias (incomplete outcome data), and reporting bias. (Selective reporting). As a result, each study's overall risk was categorized as low, moderate, or high risk based on the domains and parameters. The risk of bias evaluation for the 16 studies that were included was displayed in (Fig 2). All trials had significant methodological flaws for at least one bias area. Inadequate or nonexistent randomization (high risk in 17.85% of the trials), outcome assessor blinding (missing in 53.57% of the trials), and (unclear risk 28.57%) were the most problematic areas. (Fig 2,3) The two evaluators' reliability was strong, with a high kappa coefficient (k> 0.63).

**Study characteristics:**
The papers included in this systematic evaluation were all published between 2012 and 2022. The trials' primary results metric was the identification of stroke in patients with CVD. Six studies used Apple watches, four used Samsung smartwatches, and the final three used Huawei, Huami (amazfit health bands) and Empatica E4 smartwatches. The

wristband for the Wavelet research was used. Three different Huawei smartwatch models had been used in one research to assess the diagnostic accuracy.31 In total, 4,226 subjects participated in the research that evaluated diagnostic accuracy using smartwatches. (Table 1)

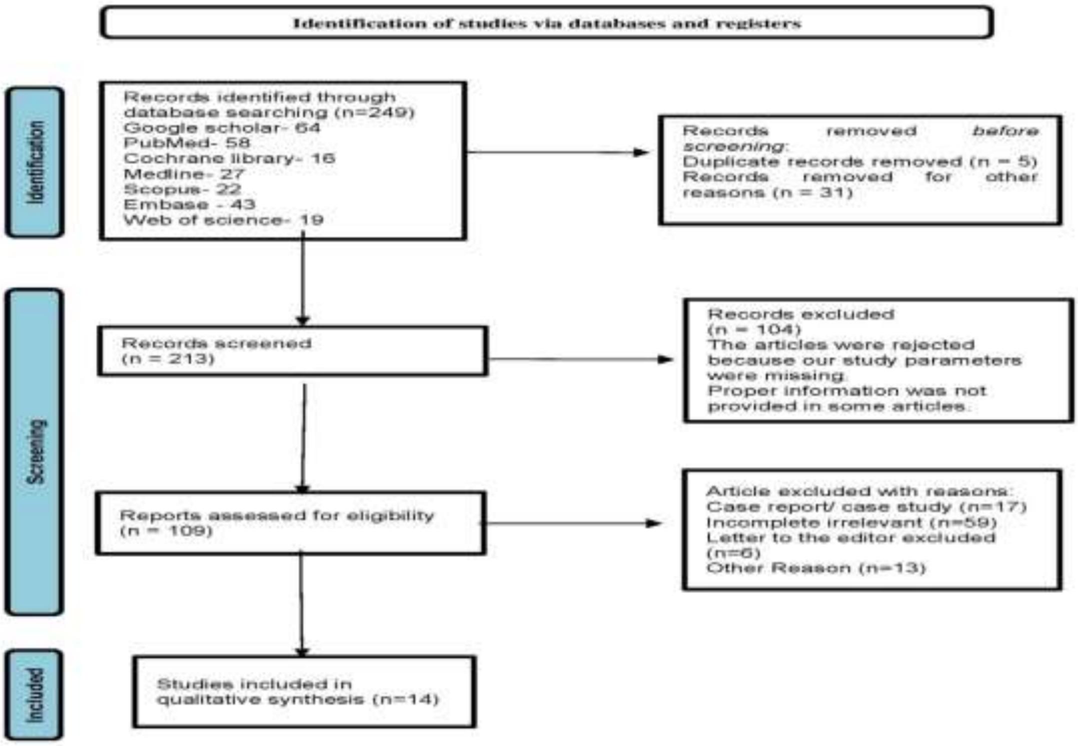


**Fig 1.** Diagram of the PRISMA process for a novel systematic review that only searched databases and registers**.**

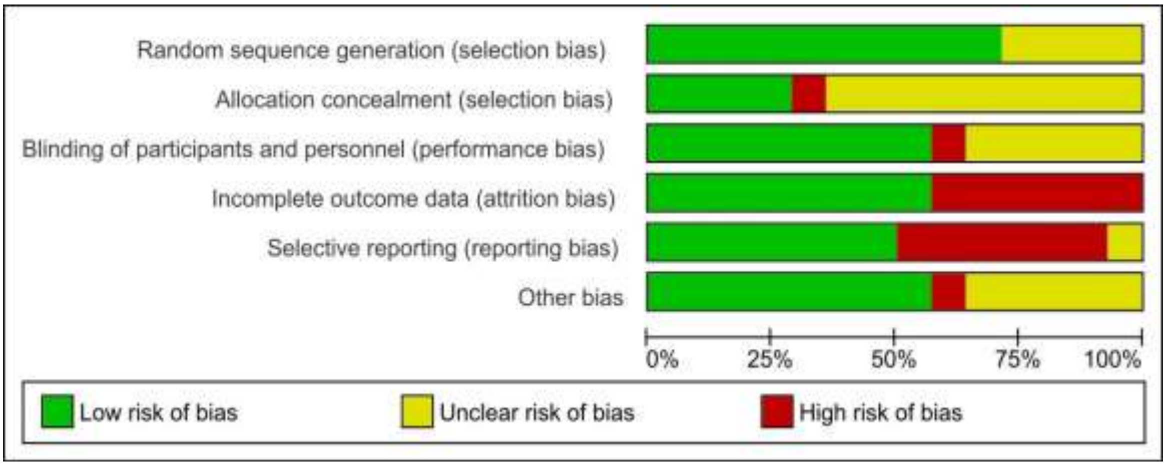


**Fig 2:** Review authors' assessments of each risk of bias item are represented as percentages across all included studies in the risk of bias graph.

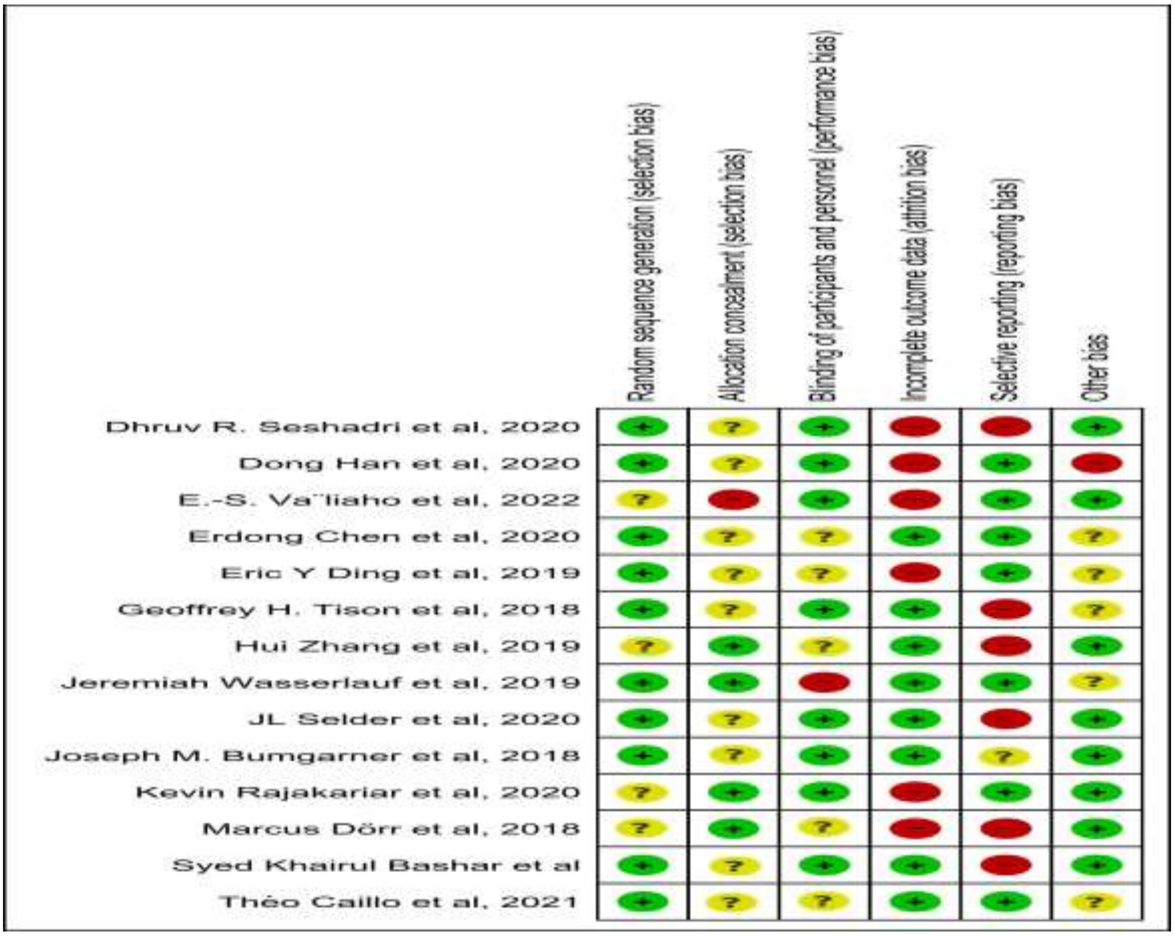


**Fig 3:** Review authors' assessments of each risk of bias item for each included research to summarize the risk of bias**.**

| **Author** | **Study design** | **Type of Smartwatch** | **Research or real-life setting** | **Type of sensor** | **Types of strokes** | **Sensitivity** | **Accuracy outcomes** | **Number of subjects** |
|---|---|---|---|---|---|---|---|---|
| Caillol et al (2021) [21] | Prospective | Apple watch | Research | PPG | AF, atrial flutter brady arrhythmias, and tachyarrhythmias | 96% | NS | 256 |
| Han et al(2020) [22] | Prospective | Samsung Gear S3 | Research | PPG | premature atrial contraction or ventricular contraction | 67% | 92% | 2 |
| Selder et al (2020)[23] | Observational, prospective cohort | Wavelet wristband | Research | PPG | AF detection | 100% | 97% | 60 |
| Seshadri et al (2020) [24] | Prospective | Apple watch | Research | PPG | AF detection | 96% | NS | 50 |
| Rajakariar et al (2020) [25] | Prospective, multicenter validation | Apple watch | Research | PPG | AF detection | 94.4% | NS | 200 |
| Chen et al (2020) [26] | Prospective | Amazfit Health Band 1S (Huami) | Research | PPG | AF detection | 96.67% | 97.51% | 401 |
| Valiaho et al (2019) [27] | Multicenter prospective case control | Empatica E4 | Research | PPG | AF detection | 96.2%/95.3% | NS | 213 |
| Wasserlauf et al (2019)[7] | Prospective | Apple watch | Research | PPG | AF detection | 83.3% | NS | 24 |
| Bashar et al (2019) [28] | Prospective | Samsung Simband | Research | PPG | AF detection | 96.15% | 97.11% | 20 |
| Dorr et al (2019) [29] | Prospective, two cen-ter, case-control | Samsung GearFit 2 | Research | PPG | AF detection | 93.7% | 96.1% | 508 |
| Ding et al (2019) [30] | Observational | Samsung Simband 2 | Research | PPG | AF detection | 98.2% | 98.1% | 40 |
| Zhang et al (2019) [31] | Pilot, cohort | Huawei Watch GT, The Honor Watch (Huawei) and The Honor Band4 (Huawei) | Real life | PPG | AF detection | 100% | NS | 263,263 and 209 |
| Tison et al (2018) [32] | Multinational, cohort | Apple watch | Research | PPG | AF detection | 67.7% | 95% | 1617 |
| Bumgarner et al (2018)[33] | Prospective, nonrandomized, | Apple watch | Research | NS | AF detection | 100% | NS | 100 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | adjudicator blinded | | | | | | | |

Short key: PPG- photoplethysmography, AF- atrial fibrillation, NS- Not stated.

**Table 1:** characteristics of the trials that were included in the detection of stroke in CVD patients**.**

**DISCUSSION:**

The diagnostic efficacy of smartwatches for all CVD has only recently been examined in this study. We have shown that it is feasible to identify heart stroke in CVD patients using currently accessible commercial technology. It is possible to obtain diagnostic accuracy for CVD in readily available smartwatches. This digital system's total sensitivity and accuracy were 91.80% and 96.11%, respectively. The goal of this study is to examine the diagnostic effectiveness of smartwatches in the early detection of stroke in individuals with CVD. The findings indicate that there are currently very few studies examining PPG technology on smartwatches and their capacity to identify arrhythmias other than AF.

The findings of the current systematic review corroborate with those of Nazarian et al. (2021), who discovered that it is feasible to diagnose cardiac arrhythmias with a high degree of diagnostic accuracy using commonly available smartwatches. These digital systems' total sensitivity, specificity, and accuracy were 100%, 95% and 97%, respectively. They identify how the area of digital disease detection is developing. Their study demonstrates that cardiac arrhythmias can be detected with good diagnostic precision by smartwatch technology. In the field of screening, the cutting-edge push of digital health devices has continued to gain momentum; this suggests that accurate evidence accumulation and regulatory standards ready to accept their introduction are crucial processes [34].

According to **Xian et al. (2017),** individuals with atrial fibrillation who experienced an acute ischemic stroke frequently received insufficient therapeutic anticoagulation. A reduced chance of moderate or severe stroke and a lower risk of hospital death were both linked to therapeutic anticoagulation. This research supports our conclusions [35].

The author of this study of smartwatch-based AF detection in patients with CVD secondary to stroke revealed that although patients generally found the pulse watch (smartwatch) system to be simple to use due to its passivity, a more focused approach on the specification of use needs to be made.

This is supported by other studies that demonstrate how easy wrist-based activity trackers are for older adults to use. The device can give accurate information to the caretaker as well as the physician without the need of active interaction in the older individuals [36].

According to **Patel et al. (2017),** an individual was successfully diagnosed with AF as the most probable cause of their stroke following a thorough negative workup. The patient's consumer wearable digital device reminded them to record ECG signals, which their electrophysiologist subsequently verified. The patient received anticoagulation to stop further strokes, so internal loop recorders (ILR) were not necessary. As these devices are more user-friendly and accessible to patients than conventional ECG monitoring devices, future research should examine their use in patients who are at a greater risk of having AF or whose management would change if they were diagnosed with AF [37].

An AFSW (accuracy of an AF-sensing watch) is more sensitive for identifying AF and gauging AF duration in an ambulatory population, according to Wasserlauf et al. (2019), when compared to an ICM (Insertable cardiac monitor). These gadgets might be a non-invasive, inexpensive substitute. Approach to AFSW (Long-Term AF Surveillance and Management) Accuracy of an AF-sensing timepiece [7].

Biosensors have achieved significant advances in early detection of various diseases including CVD and stroke by developing biosensors which captures and store information i.e. accessible free for the prediction of CVD's; these biosensors enabled with (artificial intelligence) AI captures real time vital sign such as:

1. Blood pressure
2. ECG
3. Body slash temperature
4. Respiratory rate
5. oxygen saturation

Any derangements in the above parameters send an alarm that requires medical intervention [38]. This study serves as an example of how digital disease detection is developing. Smartwatch technology currently has a good diagnostic accuracy for the identification of cardiac arrhythmias.

**CONCLUSION:**

This review determined that smartwatch technology currently has a high diagnostic accuracy for detecting the stroke in patients with CVD as well as in cardiac arrhythmias. The review summarized digital smartwatches to be effective, feasible, cost efficient and patient comfortable modalities to be used in early detection of CVD and stokes; even before the person becomes symptomatic with the growing prevalence of strokes in apparently healthy and young individuals this simple day to day used digital technology can have its best use to monitor changes in cardiac rhythms that can potentially save a life.

**BIBLIOGRAPHY:**


1. Lloyd-Jones DM, Wang TJ, Leip EP,et al. Lifetime risk for development of atrial fibrillation: the Framingham Heart Study. Circulation.2004;110:1042–1046.
2. January CT, Wann LS, Alpert JS,et al; American College of cardiology/American Heart Association Task Force on Practice Guidelines.2014 AHA/ACC/HRS guideline for the management of patients with atrial fibrillation: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol. 2014;64:e1–e76.
3. Cardiovascular disease in India Challenges and way ahead. International Heart Protection summit (Internet). Available from: http:// www2.deloitte.com/content/dam/Deloitte/in/ Documents/life-sciences-health-care/in-lshc-cardio-noexp. pdf; 2011 Cited 4.7.2015.
4. Roth, G.A., Mensah, G.A., Johnson, et al. GBD-NHLBI-JACC Global Burden of Cardiovascular Diseases Writing Group. Global burden of cardiovascular diseases and risk factors, 1990–2019: Update from the GBD 2019 study. J. Am. Coll. Cardiol. 2020, 76, 2982–3021.
5. Prieto-Avalos G, Cruz-Ramos NA, Alor-Hernández G, et al.. Wearable Devices for Physical Monitoring of Heart: A Review. Biosensors (Basel). 2022 May 2;12(5):292. doi: 10.3390/bios12050292. PMID: 35624 593; PMCID: PMC9138373.]
6. Cardiovascular Diseases-PAHO/WHO | Pan American Health Organization. Available online: https://www.paho.org/en/ topics/ cardiovascular-diseases (accessed on 17 January 2022
7. Wasserlauf et al. Smartwatch Performance for the Detection and Quantification of Atrial Fibrillation. Circ Arrhythm Electrophysiol. 2019;12:e006834.
8. Statista. 2019. Number of Connected Wearable Devices Worldwide From 2016 to 2022 URL: https://www.statista.com/ statistics/487291/global-connected-wearable-devices/
9. Nagamine K. Business Wire. 2021. IDC Forecasts Shipments of Wearable Devices to Nearly Double by 2021 as SmartWatches and New Product Categories Gain Traction URL: https://www.businesswire. com/news/home/ 20171220005110/en/IDC-Forecasts-Shipments-Wearable-Devices-Double-2021.
10. Allen J. Photoplethysmography and its application in clinical physiological measurement. Physiol Meas 2007 Mar; 28(3): R1-39. [doi: 10.1088/0967-3334/ 28/3/R01]
11. Noncommunicable Diseases (Who.Int). Available online: https://www.who.int/news-room/fact-sheets/ detail/ noncommunica blediseases (accessed on 17 January 2022).
12. Huang C, Ye S, Chen H, et al. A novel method for detection of the transition between atrial fibrillation and sinus rhythm. IEEE Trans Biomed Eng 2011 Apr;58(4):1113-1119.
13. Li Y, Tang X, Wang A, et al. Probability density distribution of delta RR intervals: a novel method for the detection ofatrial fibrillation. Australas Phys Eng Sci Med 2017 Sep;40(3):707-716.
14. Camm AJ, Corbucci G, Padeletti L. Usefulness of continuous electrocardiographic monitoring for atrial fibrillation. Am J Cardiol 2012 Jul 15;110(2):270-276.
15. Steijlen AS, Jansen KM, Albayrak A, et al. A novel 12-lead electrocardiographic system for homeuse: development and usability testing. JMIR Mhealth Uhealth 2018 Jul 30;6(7):e10126.
16. Hu MX, Lamers F, de Geus EJ, et al. Influences of lifestyle factors on cardiac autonomic nervous system activity over time. Prev Med. 2017;94:12-19. doi:10.1016/ j.ypmed.2016.11.003
17. Townsend N., Nichols M., Scarborough P, et al. Cardiovascular disease in Europe—Epidemiological update 2015. Eur. Heart J. 2015, 36, 2696–2705.
18. Mozaffarian D, Benjamin EJ, Go AS, et al. Executive summary. Circulation 2015, 131, 434–441.
19. Picano, E. Economic and biological costs of cardiac imaging. Cardiovasc. Ultrasound 2005, 3, 13.
20. Mayer F, Stahrenberg R, Gröschel K, et al. Cost-effectiveness of 7-day-Holter monitoring alone or in combination with transthoracic echocardiography in patients with cerebral ischemia. Clin Res Cardiol.

2013;102(12): 875-884. doi:10.1007/s00392-013-0601-2

21. Caillol T, Strik M, Ramirez FD, et al. Accuracy of a smartwatch-derived ECG for diagnosing bradyarrhythmias, tachyarrh ythmias, and cardiac ischemia. Circ Arrhythmia Electrophysiol 2021 Jan;14(1):009260.
22. Han D, Bashar SK, Mohagheghian F, et al. Premature atrial and ventricular contraction detection using photoplethysmographic data from a smartwatch. Sensors (Basel) 2020 Oct 05;20(19):5683
23. Selder J, Proesmans T, Breukel L, et al. Assessment of a standalone photo plethysmography (PPG) algorithm for detection of atrial fibrillation on wristband-derived data. Comput Methods Programs Biomed 2020 Dec;197:105753 [FREE Full text] [doi: 10.1016/j.cmpb.2020.105753]
24. Seshadri DR, Bittel B, Browsky D, et al. Accuracy of Apple Watch for detection of atrial fibrillation. Circulation 2020 Feb 25;141(8):702-703. [doi: 10.1161/ CIRCULATIONAHA.119.044126]
25. Rajakariar K, Koshy A, Sajeev J, et al. Smartwatch based arrhythmia detection: accuracy of clinician interpretation of unclassified tracings. Heart Lung Circ 2019;28:S228. [doi: 10.1016/ j.hlc.2019. 06. 221]
26. Chen E, Jiang J, Su R, et al. A new smart wristband equipped with an artificial intelligence algorithm to detect atrial fibrillation. Heart Rhythm 2020 May;17(5 Pt B):847-853 [FREE Full text] [doi: 10.1016/ j.hrthm.2020.01.034]
27. Väliaho E, Kuoppa P, Lipponen JA, et al. Wrist band photoplethysmography in detection of individual pulses in atrial fibrillation and algorithm-based detection of atrial fibrillation. Europace 2019 Jul 01;21(7):1031-1038. [doi: 10.1093/ europace/ euz060] [Medline: 31505594]
28. Bashar SK, Han D, Ding E, et al. Smartwatch based atrial fibrillation detection from photoplethysmography signals. Annu Int Conf IEEE Eng Med Biol Soc 2019 Jul;2019:4306-4309. [doi:10.1109/EMBC.2019.8856928] [Medline: 31946820]
29. Dörr M, Nohturfft V, Brasier N, et al. The WATCH AF Trial: Smartwatches for detection of atrial fibrillation. JACC Clin Electrophysiol 2019 Feb;5(2):199-208
30. Ding EY, Han D, Whitcomb C, et al. Accuracy and usability of a novel algorithm for detection of irregular pulse using a smartwatch among older adults: observational study. JMIR Cardio 2019 May 15;3(1):e13850
31. Zhang H, Zhang J, Li H, et al. Validation of single centre pre-mobile atrial fibrillation apps for continuous monitoring of atrial fibrillation in a real-world setting: pilot cohort study. J Med Internet Res 2019 Dec 03;21(12):e14909.
32. Tison GH, Sanchez JM, Ballinger B, et al. Passive detection of atrial fibrillation using a commercially available smartwatch. JAMA Cardiol 2018 May 01;3(5):409-416
33. Bumgarner JM, Lambert CT, Hussein AA, et al. Smartwatch algorithm for automated detection of atrial fibrillation. J Am Coll Cardiol 2018 May 29;71(21):2381-2388
34. Nazarian S, Lam K, Darzi A, et al. Diagnostic Accuracy of Smartwatches for the Detection of Cardiac Arrhythmia: Systematic Review and Meta-analysis J Med Internet Res 2021;23(8):e28974 URL: https://www. jmir.org/2021/8/e28974 doi: 10.2196/28974
35. Xian Y, O'Brien EC, Liang L, et al. Association of Preceding Antithrombotic Treatment With Acute Ischemic Stroke Severity and In-Hospital Outcomes Among Patients With Atrial Fibrillation. *JAMA*. 2017; 317(10):1057–1067. doi:10.1001/j ama.2017. 1371
36. Keogh A, Dorn JF, Walsh L, et al. Comparing the usability and acceptability of wearable sensors among older Irish adults in a real-world context: observational study. JMIR mHealth uHealth 2020;8:e15704.
37. Patel D and Tarakji KG. Smartwatch diagnosis of atrial fibrillation in patient with embolic stroke of unknown source: A case report. Cardiovasc Digit Health J. 2021 Jan 13;2(1):84-87. doi: 10.1016/j.cvdhj.2021. 01.001. PMID: 35265894; PMCID: PMC 8890063.
38. Vashistha R, Dangi AK, Kumar A, et al. Futuristic biosensors for cardiac health care: an artificial intelligence approach. 3 Biotech. 2018;8(8):358. doi:10.1007/s13205-018-1368-y

**ABBREVIATION-**

1. CVD- Cardiovascular disease
2. AF- Atrial fribrillation
3. PPG- Photo plethysmograph
4. ECG- Electrograph
5. BNP- B-type natriuretic peptide
6. CTn I- Cardiac Troponin I
7. CRP- C-reactive protein

8. CT Scans- Computerized tomography scans
9. MRI- Magnetic resonance imaging
10. PRISMA- Preferred Reporting Items for Systematic Reviews and Meta-Analyses
11. MeSH – Medical subject heading
12. ICM - Insertable cardiac monitor