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EDITORIAL COMMENT

Reducing the Global Carbon Footprint of Cardiac Arrhythmia Management*

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It is a paradox of our time that, although climate change is increasingly recognized as a risk to cardiovascular health around the world, modern health care practices continue to contribute significantly to the global carbon footprint.[1] This is unfortunately also true for the management of cardiac arrhythmias, for which there is a trade-off between the success of catheter ablation and the resultant medical waste and greenhouse gas (GHG) emissions.[2] In addition to energy consumption, catheter ablation requires the use of disposable catheters, sheaths, patches, electrodes, needles, and syringes, each in their own packaging, and all of which are discarded after use. These single-use devices and consumables' impact on the environment cannot be ignored.[3] Contemporary practices in the management of cardiac arrhythmias may therefore need to be rethought to minimize its carbon footprint. As such, the implementation of reuse or recycling of ablation catheters has been suggested to promote environmental sustainability of modern health care.[2]

In this issue of the *JACC: Advances*, Bawa et al[4] sought to evaluate the reduction in cost and GHG emissions with remote monitoring (RM) as compared to conventional monitoring of cardiac implantable electronic devices (CIEDs). The study was conducted during the COVID pandemic, during which time hospital visits were restricted to avoid potential viral exposure. As such, the authors assessed the reduction in the carbon footprint of 32,811 patients undergoing remote CIED management instead of in-person hospital visits to the dedicated 67 device clinics in the United States. This included 15,599 patients with pacemakers, 7,666 with implantable loop recorders, 5,589 with implantable cardioverter-defibrillators (ICDs), and 3,957 patients with a cardiac resynchronization therapy with a pacemaker and an ICD (CRT-D). Their remote follow-up resulted in an estimated reduction of 31.7 million miles in distance traveled for CIED monitoring and a 12,518 metric ton reduction in CO_2 production from regular gasoline burnt in a standard passenger vehicle in the United States. These savings on GHG emissions are merely the tip of the iceberg, considering that up to 1.4 million CIEDs are implanted across the world every year.[5] In addition to the favorable impact on the environment, the authors also suggest that remote follow-up was cost-effective, with an estimated $3.45 million that was saved on traveling costs in their study.

Regular follow-up and monitoring after CIED implantation ensure patient safety.[5-8] In this regard, implantable loop recorder interrogations allow clinicians to take action if the device detected an arrhythmia that would benefit from pacing and/or an ICD. Pacemaker and ICD interrogations allow for optimization of device settings, with the aim of improving physiological pacing, maximizing longevity of the pulse generator and, in the case of ICDs, avoiding inappropriate shocks.[6] Infrequent interrogations, however, would result in a delay in clinical decision-making and optimization of therapy. The frequency of follow-up depends of course on the underlying cardiac condition, the kind of CIED, and whether follow-up is planned to be conducted in-person at a device clinic only, or in a hybrid manner, that is, both in-person and remotely. As recommended by contemporary guidelines, CIED interrogation should be conducted in-office for the

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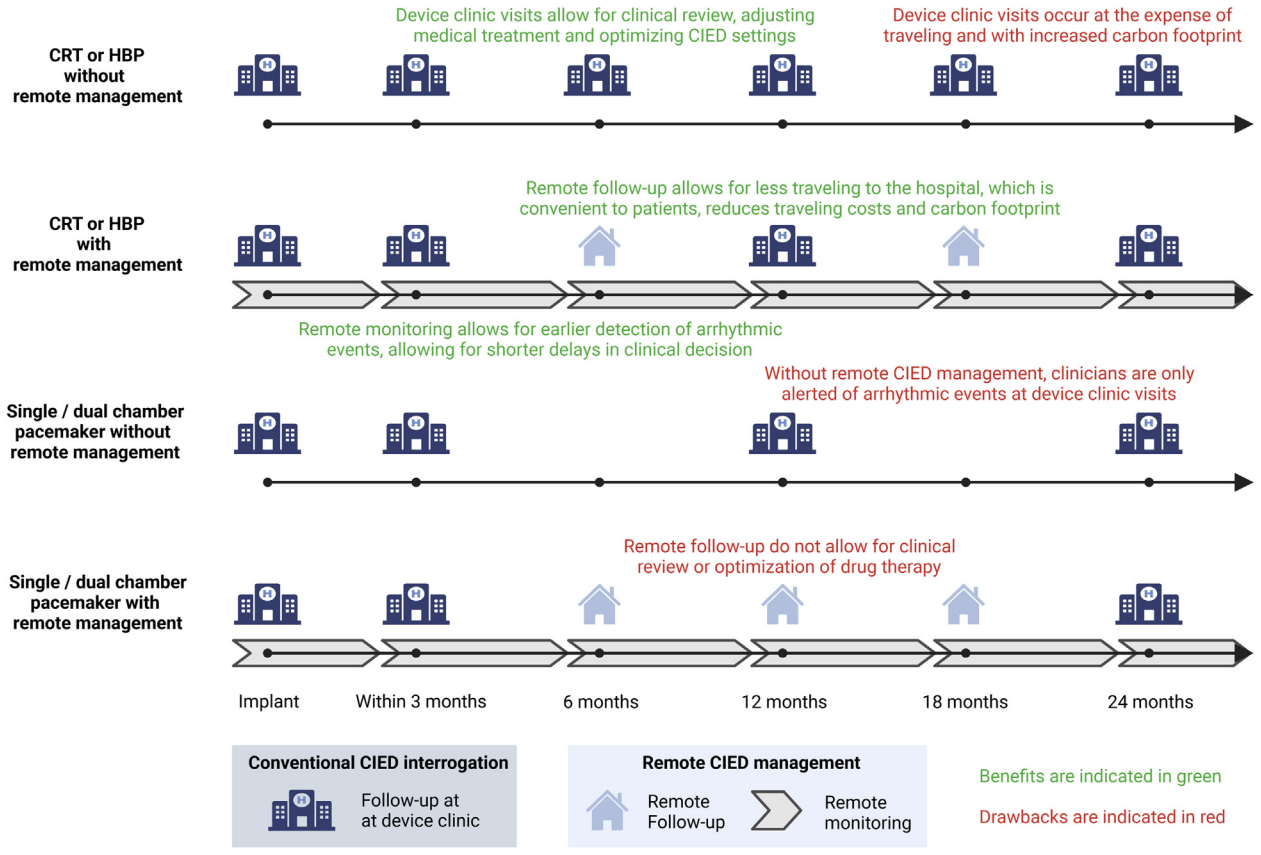
FIGURE 1 Regular Follow-Up and Monitoring After CIED Implantation Ensures Patient Safety



The frequency of follow-up depends on the kind of CIED, and whether follow-up is planned to be conducted in-person at a device clinic only, or in a hybrid manner, both in-person and remotely.[4-7] Each follow-up strategy has advantages and disadvantages, as annotated in **green** (benefits) and **red** (drawbacks). CIED = cardiac implantable electronic device; CRT= cardiac resynchronization therapy; HBP = His bundle pacing.

first visit after implantation, which is usually within the first 3 months (Figure 1). Thereafter, in the absence of remote CIED management, CRT and His bundle pacing require 6 monthly visits to a dedicated device clinic, whereas single- or dual-chamber pacemakers could be interrogated every 12 months. Remote CIED management allows for less frequent device clinic visits. Whereas all devices require 6 monthly remote follow-up, in-person device clinic visits could be reduced to once every 12 months for patients with CRT or His bundle pacing, or once every 18 or 24 months for patients with single- or dual-chamber pacemakers.[6,9,10] Remote follow-up may be more convenient for patients with limited mobility or those with professional or family commitments. However, more frequent in-person visits are recommended in patients with heart failure and frequent arrhythmic events. Indeed, the disadvantage of remote follow-up visits is that patients cannot be reviewed clinically, and their medical therapy cannot appropriately be adjusted by the physician at the device clinic. Unfortunately, it was not reported how many patients developed decompensated cardiac failure, or had inappropriate shocks, during the time of less frequent visits to the device clinic.

The term remote CIED management encompasses both RM and remote follow-up. RM (ie, unscheduled transmission of an alert of an arrhythmic event that may require action) needs to be differentiated from remote follow-up (ie, scheduled follow-up to interrogate the CIED). It has previously been shown that although RM reduced overall hospital visits, it allowed for events to be detected that mandated more unscheduled visits.[11] Indeed, RM allows for shorter delays in clinical decision-making after arrhythmic events are detected. This may, for

instance, reduce the number of inappropriate shocks from an ICD[12] or facilitate earlier commencement of oral anticoagulation to prevent stroke in the setting of device-detected atrial fibrillation,[13] which is a benefit of remote CIED management over in-office device interrogation only. However, this benefit of RM is only effective if there is a timely response to alerts and requires technologists that are dedicated to RM.

In addition to the favorable impact on the environment, the authors found that remote CIED management resulted in improved workforce efficiency, with one cardiac technologist needed for 1,500 CIEDs monitored remotely, for the same time it would take one cardiac technologist to conduct 500 CIEDs interrogations during conventional in-person device clinic visits. This supports the literature suggesting that RM can reduce the workload on clinical staff when conducted by third party providers who triage CIED alerts of cardiac arrhythmias.[14] This, however, requires special patient consent and strict protection of personal information by all stakeholders.[15]

As climate change is a major challenge to mankind and health care continues to contribute significantly to global CO_2 emissions, we need to find solutions for how modern health care practices can become environmentally sustainable. In this regard, an increase in the implementation of remote CIED management could significantly reduce GHG emissions. Although the reuse of pacemakers has previously been shown to be safe,[16] and reuse and recycle of ablation catheters have been suggested,[2] more research is needed to determine whether these alternative practices would effectively reduce the global carbon footprint, at the same time as providing optimal management of cardiac arrhythmias.

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