Big data and the future of cochlear implant aftercare

BY ANDREAS BÜCHNER

With a million people using cochlear implants worldwide, the time is right for us to harness this vast data for patient benefit.

Every day, cochlear implant (CI) processors quietly collect data: how long they're worn, how often users switch programs and what kinds of sound environments they encounter. In addition, many CI users now engage with companion apps that offer basic hearing tests, device status checks and even impedance measurements.

Until recently, most of this information was only reviewed during in-clinic appointments – visible to clinicians and used primarily for counselling or troubleshooting. But what if we could turn this wealth of data into something more? Something that helps us fine-tune fittings, detect complications early and support patients where they are?

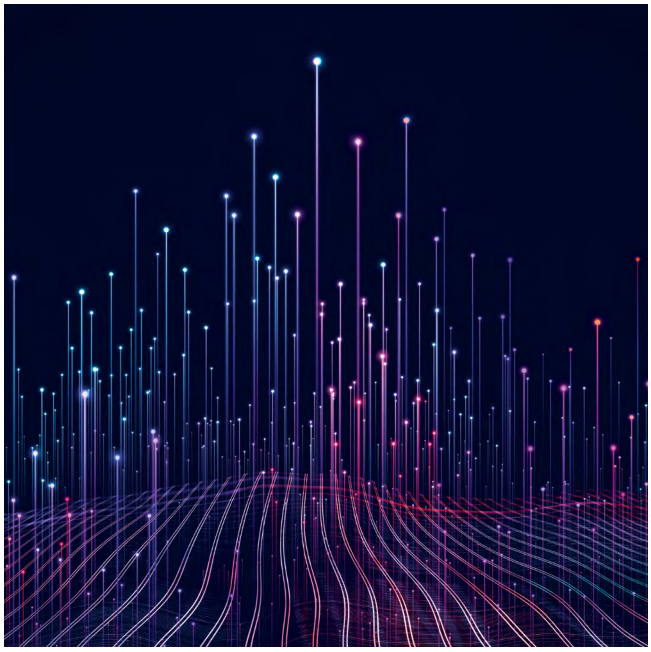
That's the promise of big data in CI care. With thousands of CI users and implants generating data in real time, and smartphones increasingly serving as both gateways and active data collection tools, we are entering a new era of aftercare – one that is more personalised, more responsive and more sustainable.

A growing data universe

Today's CI systems collect a rich array of information: from datalogging on device usage, listening environments and connectivity status, to telemetry data from individual electrodes. They also track sound processor events such as coil-offs or error flags. In addition, structured remote hearing checks, repair logs and replacement events add further depth to this growing digital footprint. These data points, when collected longitudinally and interpreted in context, can support better diagnostics, early warning systems and personalised care.

As an example, we recently explored how electrode impedance behaves in the early postoperative phase following cochlear implantation – particularly before and right after the onset of electrical stimulation. Using a smartphone app, patients conducted self-measurements at home, twice a day, over several months. Compared to traditional in-clinic snapshots, this approach offered a far more detailed picture of impedance behaviour during this critical period.

Daily impedance measurements allowed us to observe patterns such as morning-to-evening fluctuations and dynamic changes that may reflect underlying physiological events. For example, impedance tended to rise when patients reported a cold, and decreased in response to steroid-based medication, such as asthma sprays. These findings suggest that real-time impedance tracking could enable early detection of intracochlear inflammation or other adverse conditions – prompting timely clinical intervention. Interestingly, patients showed a high level of motivation, with most continuing to measure regularly over weeks and months. This level of engagement suggests that, with the right tools, CI users are willing and able to take a more active role in their own care.



First steps in remote CI care

Cochlear was the first to roll out a remote follow-up app with Remote Check, introduced in 2020. It offers CI users the ability to complete structured follow-up tasks from home, including:

- Validated questionnaires on hearing and wellbeing.
- Impedance measurements and usage statistics.
- Speech perception tasks and aided thresholds using the patient's own device.
- The option to upload photos of the implant site for clinician review.

While Remote Check does not include remote fitting or data-driven adjustments, it laid the groundwork for structured asynchronous follow-up, reducing the need for in-person appointments and providing valuable information to clinicians between visits. One limitation, however, is that patients must be invited by the clinic to access the self-check functionality. This requirement adds an unnecessary hurdle, particularly when the goal is to gather real-world data and continuously monitor patient health.

MED-EL's HearCare platform offers a growing range of tools for remote support and follow-up. CI users can:

- Perform impedance measurements from home.
- Receive new MAPs pushed directly to their processor.
- Conduct a system check to troubleshoot technical problems.
- Back up their configuration for quick restoration in case of processor loss or damage.

HearCare also enables targeted support. One recent case involved a patient struggling with booming low frequencies when attending

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a concert. A low-frequency-reduced MAP was sent via the app, tested in the real environment and, based on immediate patient feedback, fine-tuned again – all without a clinic appointment. In the end, the patient reported a clearly improved listening experience with the final program. This example illustrates how remote systems can enhance both responsiveness and personalisation in aftercare. At the same time, it raises important questions about how audiologists' time and expertise are reimbursed in these evolving care models.

Advanced Bionics has also recently introduced a remote care app, called AB ListenFit. It enables patients to perform structured self-assessments using standardised audiometric tools, including the Matrix sentence-in-noise test (available in multiple languages), a digits-in-noise test, a phoneme discrimination task and a soft sound detection test. The app also supports bimodal users. Although impedance measurements and program adjustments are not yet possible via the app, AB ListenFit still represents a meaningful step forward in gathering standardised audiometric outcome data beyond the clinic setting.

Still, the potential goes further

Regarding aftercare, there is much more which could be given into the hands of the patients. For example, Cochlear already allow limited patient-driven adjustments via their app. However, patients currently cannot create and save customised programs for different listening environments – something that was made possible in a research project with Advanced Bionics. In that project, users were given two different graphical interfaces to adjust their settings in real-world scenarios. They could save preferred configurations and later revisit or refine them in everyday life based on their listening needs. If such self-adjustments were carried out at scale, combined with contextual acoustic classification data, they could generate vast and valuable datasets. These could be mined using AI and big data approaches to better understand user preferences and optimise sound processor performance for different listening situations.

The role of AI and predictive modelling

As data volumes grow, the integration of machine learning and AI-driven analytics becomes increasingly relevant. With access to large-scale, real-world data, these systems could detect usage anomalies, suggest personalised fitting adjustments or flag high-risk patients for early follow-up.

To fully realise this potential, we cannot solely rely on closed manufacturer-specific platforms. While manufacturers will likely continue to manage their own apps and ecosystems, there is promising movement toward offering interfaces that would allow clinicians to access and integrate patient data into their own clinical systems or even into national registries. In the long term, the field of audiology would greatly benefit from standardised data structures that support pooling of anonymised data across manufacturers, clinics, and even across countries. While this remains a distant goal, it is an important step toward enabling cross-platform, large-scale learning and innovation in cochlear implant care.

To truly leverage AI, we will need massive datasets – far beyond what is captured during annual check-ups. With continuous input from user behaviour, self-adjustments, impedance telemetry and sound environment classification, AI could do more than assist clinicians in decision-making: it could uncover patterns and insights that are simply invisible within today's follow-up models.

Challenges and future directions

While the first building blocks for remote care – apps supporting specific follow-up tasks – are already available and clearly helpful, they remain manufacturer-specific, limited in scope and not yet fully integrated into routine clinical workflows. Each platform offers certain strengths – such as impedance monitoring, remote MAP delivery, or structured self-assessments – but none currently provide the comprehensive functionality needed to truly replace a full clinical visit. That said, all platforms are steadily evolving in the right direction, reflecting a shared recognition of the need for more flexible and data-driven care options.

What's needed now is a joint effort across the field: manufacturers, clinical bodies and patient groups must collaborate to develop standards, policies and workflows that make data-driven CI care safe, scalable and accessible for all.

Conclusion: empowering patients, enriching care

Cochlear implants are no longer just implanted devices – they're part of an evolving digital ecosystem. With smart apps, remote diagnostics and big data analytics, we can offer CI users more autonomy, more safety and more personalised hearing care.

The technology is here. What we need now is the will – and the systems – to fully harness it.

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