



Lessons from Covid-19 and the potential benefit of the implementation of Axon's personal electronic health records (PEHR) into aesthetic care, plastic and reconstructive surgery

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Abstract

Background Covid-19 pandemic highlighted the need for implementing Personal Electronic Health Records (PEHR) for patients' data management. Furthermore, this pandemic underscored the relevance for integrated and interoperable Electronic Health Records (EHR) to support disease surveillance, hospital capacity planning and resource management (Peek N, Sujan M, Scott P (2020) Digital health and care in pandemic times: impact of COVID-19. *BMJ Health Care Inf* 27(1):e100166. <https://doi.org/10.1136/bmjhci-2020-100166>). Due to the lack of comprehensive patients' record in plastic, reconstructive and aesthetic surgery, Axon's myHealth app offers a break-through patient-centric design allowing patients to be in control of their records and updating them in real-time for their plastic and aesthetic care providers to have a clearer understanding of patients' history and progress from pre-op to post-op.

Methods The Axon Dublin survey took place during Covid-19 pandemic in two phases: Phase 1 aimed to assess the feasibility of patients integrating the Axon myHealth application into their clinical visits. Testing occurred in a clinical environment, where patients were encouraged to download and use the Axon system with a health practitioner (HP) present. Phase 2 focused on home testing, evaluating patients' willingness to manage their health remotely with HP assistance. This phase included self-testing activities such as performing rapid Covid-19 antigen tests, recording medical history, and measuring blood pressure at home.

Results The Axon Dublin Study aimed to assess patient engagement, clinical impact, and cost-effectiveness of the Axon myHealth application. Over 85% of patients showed interest in owning a Personal Electronic Health Record. Notably, 36% continuously monitored chronic conditions. Clinical decisions, informed by patient data, saw 61.9% compliance. Noteworthy, 23% of hypertensive participants required immediate medication changes. Patient self-capture of data reduced consultation time. Public health implications were significant, with 39% vaccinated and 31% reporting complications. High user satisfaction (97%) demonstrated the app's effectiveness in infection control and chronic care.

Conclusions Offering patients the ability to update and control their data is a growing interest, with a clear need in plastic and aesthetic surgery to have a better understanding of a patient's medical past and progress throughout the surgical process and period. This platform, which is time and cost efficient, can only facilitate personalised care and improve outcomes while maintaining patient's confidentiality.

Level of evidence Not gradable.

Keywords Electronic Health records · Plastic surgery · Covid-19 · Digitalization · Data Management

Introduction

Upon the development of modern medicine, the approach changed towards highly-specialised doctors, which resulted in patients having multiple competent doctors each in their respective fields providing the best quality care possible. Such an approach raises a significant concern around the phenomenon of fragmented care [2], where the lack of coordination and communication between medical providers in different domains can result in fragmented medical records, which eventually will impact the patient's well-being and health care.

In the context of patient's medical records in plastic, reconstructive and especially aesthetic surgery, the patients choose to switch their aesthetic care provider because of their dissatisfaction with a certain procedure or merely because they seek a second opinion. Either way, the data provided are often ignored or incomplete for a multitude of reasons that vary from the lack of awareness and assuming that this information serves no relevance for comprehensive documentation, to purposefully leaving that information out or not providing the full picture due to the desire to maintain confidentiality. Moreover, patients may not fully disclose their previous treatments or complications, either because they are unaware of the relevance of this information or they wish to keep certain details private. Nevertheless, this can lead to complications and directly affect the quality of care provided by surgeons [3].

Furthermore, for plastic, reconstructive and aesthetic surgeons, a detailed patient history is of critical importance because of the surgeons' responsibility to make an informed decision, mitigate risks and ensure optimal patient outcomes in cosmetic and reconstructive procedures [3]. Comprehensive documentation and the accessibility to the data through electronic health systems can contribute significantly to treatment planning, procedural safety, and the overall quality of care provided [4, 5].

The sudden emergence of the Covid-19 pandemic posed significant challenges in relation to general medical practices, particularly around the maintenance of data and the production of documentation. Covid-19 revealed the vulnerabilities and gaps at the core of a lot of these which both the public and health authorities relied upon. This served as a seminal moment that these processes needed to be changed to meet the critical needs of a new information age [1]. The failure to generate and access reliable real-time data was identified as a major shortcoming and a critical lesson learned from the Covid-19 pandemic. In a study across the UK, a cross sectional survey among aesthetic plastic surgeons was conducted to assess the impact of Covid-19 pandemic on their field and practice, with a large number of the participants stating that they introduced telemedicine

and digitalization as a solution for follow ups with patients [6, 7]. This approach demonstrates many limitations, among which include, the inability to conduct a physical examination or the lack of access to high-speed internet pose significant challenges from both a practical and technical standpoint.

The Covid-19 pandemic underscored the importance of implementing change and technology on a broader scale, with elevated standards, seamlessly integrating them into medical practice. This approach aims to enhance rather than replace traditional methods of doctor-patient interactions, maximising their effectiveness and improving overall healthcare outcomes. An example of such an enhancement opportunity was the unprecedented advancement of telemedicine technologies during the Covid-19 pandemic [8].

One technology that was integrated into the practice of plastic and aesthetic surgery is Axon's mobile phone application, myHealth, for patients and the Axon Health Professional mobile phone application for health professionals. These applications were readily available for download from the Apple Store or Google Play Store during the Dublin Study, enabling users to register and intuitively enter personal and relevant health information. Even though there are other mobile EHR applications, the closest other solutions that share similar functionalities with Axon's solution would be Symplast, Nextech and PatientNow. However, these are practice management software whereas Axons solution is a mobile application [9, 10 and 11].

The integration of EHRs in medical practices has shown potential to improve patient outcomes through better data management, enhanced communication between patients and healthcare providers, and more informed clinical decision-making. However, the adoption of such technologies in plastic and aesthetic surgery has been limited. This study aimed to address this gap by evaluating the feasibility and benefits of using the Axon myHealth application in these fields.

The objectives of the study were to assess patient participation in uploading health information, evaluate the willingness of health practitioners to use this data for clinical decision-making, and examine the potential time and cost savings. Additionally, the study aimed to explore the broader public health impact of implementing such a solution on a larger scale.

By integrating these objectives into the study, we aimed to contribute to the field of plastic and aesthetic surgery by providing evidence on the usability and benefits of a patient-centric EHR solution. This could lead to more efficient patient management, improved clinical outcomes, and a more proactive approach to public health within this specialty.

Objectives

The Axon Dublin Study was designed to achieve the aims by following the objectives hereafter:

- 1. Patient Participation: The study evaluated patients' willingness and ability to upload meaningful, usable health and medical information to the Axon MyHealth application.
- 2. Clinical decision making: The study evaluated health practitioners' willingness to use patient-uploaded health data for clinical decision-making. For instance, 21 people were tested for hypertension, with 23% recommended an immediate change of medication and 25% newly diagnosed with hypertension.
- 3. Evaluate time and cost savings: The study examined the potential time and cost savings for health practitioners. Capturing medical health history typically takes 7.3–9.3 min of the HP's time [18–19], most of which was saved by patients capturing their own data without using the HP's time in the Axon Dublin Study.
- 4. Public Health Impact: The study aimed to explore the possibility of implementing Axon's solution on a larger scale population for micro-managing health records. It assessed the application's ability to advance public health by examining the potential of generating proactive public health guidelines based on real-time clinical data.

Methods

The study was conducted in two phases, each with distinct objectives and methodologies. The two phases were run concurrently.

Phase 1 The first phase took place from 10th November 2021 to 31st May 2022. During this period, 240 patients participated in testing within a clinical environment. The primary objective was to assess the willingness of patients to download and use the Axon system with a HP in a clinical setting. In-person consultations allowed HPs to record clinical observations and Covid-19 test results, which were accessible to patients in real-time via the Axon myHealth application. Additionally, the myHealth application facilitated the documentation of received Covid-19 vaccines and the reporting of any complications or side effects to the HP in real-time.

Phase 2 The second phase occurred from 1st April 2022 to 31st May 2022 and focused on testing at home. This

phase aimed to evaluate whether patients were willing to manage their basic health remotely with assistance from HPs. Patients were tasked with performing Rapid Covid-19 Antigen Self-Tests at home and uploading their results as pictures for Axon HP validation. They also recorded their medical history and blood pressure at home.

Participant details and criteria:

- Number of patients: 240.
- Exclusion criteria (for both phases):
 - Individuals under 18 and over 90 years old.
 - Individuals without smart devices.
 - For Phase 1: Individuals with a Covid-19 infection at least one week before their test appointment.
- Inclusion criteria (for both phases):
 - Open invitation for those willing to purchase for Covid-19 testing service.
 - Individuals ready to download the application.
 - Individuals willing to connect and share their results with the Health Practitioner.
 - For Phase 2: Individuals with a blood pressure monitor machine.

Representativeness of the sample:

While the sample was diverse, it cannot be viewed as fully representative of the general population. The diversity of the participants provided valuable insights, but limitations in the sample's representativeness should be acknowledged.

Division of study phases and objectives:

- Phase 1: This phase involved testing in a clinical environment to prove the feasibility of patients downloading and using the Axon system with a HP present. The goal was to ensure patients were comfortable and willing to integrate the Axon myHealth application into their clinical visits.
- Phase 2: This phase focused on home testing to evaluate the willingness of patients to manage their health with remote assistance from HPs. It included self-testing activities such as performing rapid Covid-19 antigen tests, recording medical history, and measuring blood pressure at home.

Statistical methods:

The data was analysed using basic comparative methods to summarise, compare, and interpret the findings.

Comparative analysis:

- Proportions and percentages were calculated to compare new detections and recommended actions. 85.8% of the total patients were participating in phase 1 while phase 2 there were 31.3%. In Phase 2, 61.9% of participants followed the recommended actions. Overall user satisfaction was 97%.

Descriptive statistics:

- Means and averages summarised key metrics like the average number of tests conducted and user satisfaction levels.

Correlation analysis:

- The relationship between daily logging and health monitoring showed that 36% of Phase 1 participants continuously monitored their conditions. Over 81% of participants expressed interest in owning their electronic health record.

Handling of missing data:

- Missing data were removed and excluded from the analysis to ensure the results and conclusions were accurate.

These methods highlighted significant differences in engagement, adherence to recommendations, and high levels of user satisfaction across both phases.

Results

The Axon Dublin Study aimed to assess patient participation, clinical decision-making, time and cost savings, and public health impact through the integration of the Axon myHealth application in plastic and aesthetic surgery practices.

Patient participation:

- 85.8% ($n=240$) of patients participated in Phase 1; Covid-19 testing within a clinical environment, demonstrating significant engagement.
- 31.3% ($n=240$) of patients participated in Phase 2; recording their chronic conditions during the study, despite none doing so before the study.
- 81% ($n=221$) of users expressed interest in owning a PEHR solution, indicating a shift towards patient-centred healthcare.

Clinical decision making:

- Health practitioners utilised patient-uploaded health data for clinical decision-making. In Phase 2, 61.9% ($n=21$) of participants followed the recommended actions provided by health practitioners.
- 23% ($n=13$) of participants with existing hypertension were recommended an immediate change of medication, and 25% ($n=8$) were newly diagnosed with hypertension.

Time and cost savings:

- Capturing medical health history typically takes 7.3–9.3 min of the HP's time [18–19]. This time was saved by patients capturing their own data without using the HP's time in the Axon Dublin Study, highlighting potential efficiency gains.

Public health impact:

- The study explored the potential of implementing Axon's solution on a larger scale for micro-managing health records. It assessed the application's ability to advance public health by generating proactive public health guidelines based on real-time clinical data.
- Among the participants, 39% ($n=75$) were vaccinated against Covid-19, while 5% ($n=75$) were not, 54% preferred not to answer. Complications were reported by 31% ($n=75$). Regarding subsequent vaccinations, 36% ($n=75$) agreed to a second vaccine, 3% ($n=75$) declined, and 27% ($n=75$) agreed to a booster vaccine.

The high level of user satisfaction, with 97% ($n=221$) of respondents expressing satisfaction with the Axon myHealth app, demonstrated the app's effectiveness in monitoring and limiting infection outbreaks while offering appropriate healthcare services for continuing chronic medical problems.

Health professionals found the application valuable for immediate access to critical data, reducing consultation time and costs. The study also highlighted the potential of the application in generating Big Data for public health management, aiding real-time interpretation and adjustments in health guidelines, particularly during pandemics.

Discussion

Axon Evolution proposed a disruptive design model where individual patients become the controllers and managers of their health information stored in their PEHR systems. This model transfers the responsibility for management, consent, and third-party sharing to the individual patient. By

empowering patients with control over both data input and data sharing, this design revolutionises the ownership and management roles in the individual's health information. In many countries, patients often rely on health services to store and manage their health data, rather than having direct control themselves. For instance, the American Medical Association (AMA) highlighted that even though there is significant support for better patient access to health data, that the current infrastructure often requires health-care providers to manage and exchange this information. This dependency on providers can result in limitations for patients to access their health information [12].

In 2021, the Verdict from a Citizen's Jury on access to Health Information in Ireland [13], supported a model for the right of citizens to access, manage, and decide on sharing of their own health data.

This supports the Axon Evolution solution and model, giving control to the individual client to create and manage a repository of medical information created by the patient and professional health care practitioners and managing and sharing this information as appropriate.

The design of this model holds significant potential for adoption within the realm of plastic surgery and aesthetics, primarily because of the unique relationship between plastic surgeons or aesthetic care providers and their patients, often characterised by a lack of comprehensive documentation, including a comprehensive medical, surgical, treatment and medication history. Comprehensive medical documentation in plastic surgery and aesthetic practices is crucial and yet often neglected. According to an article on Elite Med Listings, robust documentation is essential for patient safety, medico-legal defence and maintaining a practice's reputation. This is critical as incomplete or inaccurate records can lead to preventable errors, inadequate care and increased vulnerability to lawsuits [14]. As demonstrated by the study conducted during the Covid-19 pandemic, the applicability of this template in plastic, reconstructive, and aesthetic surgery is evident, as Axon's model successfully achieved its outlined objectives. The importance of adopting comprehensive documentation practices within this field is key to addressing and managing continuity of care, informed decision making and effective patient management [15].

According to a study in 2019, The authors conducted a thorough examination of the impact of Electronic Health Record (EHR) adoption on an oculoplastic practice. The evaluation carried out a detailed analysis of clinical volume, reimbursement, and the overall experience and satisfaction of patients. The application of (EHR) increased the devoted time of the physician to patient care, while the patients experienced fewer waiting times concurrently with growing satisfaction [16].

A common perceived issue with (EHR) is the barriers to a user-friendly interface. Axon's solution benefits from a team led by medical professionals who have conducted thorough UI tests focused on usability. Moreover, the app offers immediate advantages through user-centric data submissions and integrates a range of health-related functions into a single platform, effectively serving as an all-in-one tool for health management. Research highlighted by the BMJ shows that a user-friendly interface could minimise the burden on clinicians while maximising the benefits for healthcare providers and patients and would greatly improve healthcare delivery quality and efficiency [15].

The Dublin Study examined the use of customised questionnaires relevant to the history and symptoms for the visit, in this case Covid-19 assessment. The questions specifically answered the typical questions that the GP would have asked, and information gathered as part of the history taken during the routine consultation. The patient completed and submitted this information to the GP prior to the consultation and the GP could review this detailed information and start with the examination consultation after reviewing the history, saving considerable time to take and record the history. Similarly, customised questionnaires could be designed and completed for various Plastic and Aesthetic Medicine first, and follow up consultations to record detailed medical history, prior to the consultation [17].

Furthermore, two separate studies indicated that the average consultation time it takes for general health practitioners in the UK is around 9.24 min [18]. Whereas similarly, the average time in the USA is between 9.24 and 21.07 min [19]. This clearly highlights the importance of effectively evaluating time and cost savings for both health practitioners and patients alike.

In addition, under time pressure to take a history, examine and treat a patient, GP's asked less questions concerning presenting symptoms, than the ones indicated by the guidelines, ($p=0.019$), conducted a less-thorough examination ($p=0.028$) and gave less advice on lifestyle ($p=0.05$) [20].

It is generally accepted that 30% of consultation time on average is allocated to history taking. By submitting a detailed medical history prior to the consultation, a significant amount of time is saved to take and record medical history. However, within the realm of plastic surgery and aesthetics, having pre-filled patient history through an EHR mobile application would streamline the initial consultation process which will allow for a more in-depth discussion and personalised treatment plans. The benefits of such are clearly demonstrated by Symplast's solution [9] which was further supported by authors Workman & Gupta who argued that the applicability of using smartphone applications has the potential to change future patient - surgeon interactions

by offering more personalised and user-friendly encounters [21].

The Axon Evolution model prioritises enhancing the accuracy and accessibility of patient data, including history, aiming to facilitate real-time interaction and access to up-to-date information provided by patients. This approach contributes to improving the overall patient experience and enables the development of personalised treatment plans, ultimately leading to better outcomes, by allowing more time for the examination, treatment plan and prescription generation. Plastic surgery patients can efficiently update their health information, including postoperative care details, allergies, previous surgeries, medications, and medical history. By adopting this patient-centric model, patients have full control over their health data. On the one hand, the benefits of personalization in aesthetic surgery means that it enables aesthetic surgeons to take into consideration a patient's current medical conditions, physical limitations and lifestyle factors before proposing a treatment plan which ultimately gives the surgeon more time to develop a proposed treatment plan. On the other hand, the authors of the American Society Of Plastic Surgeons noted that patient satisfaction post-surgery is directly affected by surgeon related factors such as taking the time to answer questions and including patients in the decision making process. Which, with Axon Evolutions' solution, could make this a reality [22].

AI-Driven Predictive Healthcare, with such AI capabilities, the Axon app would surpass other apps by providing tailored aesthetic recommendations and predictions with a dynamic adaptation into the interface. This feature would not only offer the user the ability to understand their aesthetic goals but also facilitate plastic surgeons in pre-operative planning and making informed decisions during consultations. Such a machine learning algorithm can analyse a multitude of aesthetic data, including facial features, proportions and surgical outcomes for similar cases, optimising results in the process [23]. A notable example of AI application in healthcare is the FDA approved CLEWICU which is an AI driven tool designed to predict hemodynamic instability in ICU patients using advanced algorithms to analyse data which provides critical insights to prevent life-threatening situations [24].

The biggest concern when it comes to implementing (EHR) is regarding the ethical point of view and data security, because of the vulnerabilities that the complexity of AI generates for possible intrusions, cybersecurity becomes a critical worry [25–27]. Hence the implementation of strict guidelines and regulations to create a balance between protecting the patients' data and promoting innovative approaches in aesthetic healthcare. General Data Protection Regulation (GDPR) and other personal health data protection measures have played a crucial

role in addressing these concerns [28]. Axon Evolution managed this concern by building a framework that prioritises patient privacy by creating a robust security structure.

Shaping an infrastructure that achieves seamless interoperability between different healthcare IT platforms is a key element in the success of (EHR). Standardised data formatting and secure data exchange protocols are necessary to establish a sustainable model [29–31]. More investments and policies are required by policy makers and healthcare stakeholders to enable an exchange of information across platforms securely and efficiently.

In summary, with a growing trend towards the management of (EHR) to be in the hands of the patient supported by modern technology, Axon's Dublin Study's aim is exploring the potential benefit of a futuristic (EHR) solution to transform the interaction between patients and aesthetic care providers towards a more convenient, personalised, secure and informative approach with a strong emphasis on patient involvement. The challenge remains as this solution is out of the norm of what patients are used to. Nevertheless, the suggested design strategies by the Axon Dublin Study explored the enhancement potential for the user interface to trigger engagement through conscious and subconscious methods.

In today's plastic, reconstructive and aesthetic surgery world, efficient data retrieval and decision-making processes are pivotal for optimal outcomes, yet it is held back by the outdated patient management systems. The study's exploration of time and cost savings serves as a template for optimising plastic, reconstructive and aesthetic care workflow.

In an era of accelerating advancements, acknowledging the significance of a science-based and evidence-driven approach to aesthetic surgery is long overdue. The current study intends to assess the evidence available regarding both the advantages as well as the drawbacks of this technology in documenting the results of aesthetic procedures [32].

A major advantage of the Axon system is the ability for users to share their data with complete anonymity for research and developmental purposes. This data, when collected at a large scale will become a valuable asset for the AI and machine learning algorithms to become more capable and most importantly more precise in the prediction of an aesthetic procedure.

The application of this methodology to the Covid-19 pandemic showcases the ability of extending the use of this technology to become a cornerstone in the development of patients' interaction with their plastic surgeons and aesthetic care providers in a transformative innovative way to shift the paradigm into a more patient-centric, data-driven and responsive system, as highlighted in Axon's Dublin study.

Conclusions

The Axon Dublin Study demonstrated that the overwhelming majority of patients were ready to take control over their health and medical records as long as they had a user friendly and secure solution. These records were shared with HPs, potentially improving the quality of decision making as well as contributing to higher efficiency in patient service.

Prior to the Axon Dublin Study most patients had not maintained their health records but relied on their various HPs. Axon offers a solution for improving the accuracy of medical decisions. This is especially valid in the case of plastic and aesthetic practices where surgeons often have limited access to prior patient health events. The regular use of a fully documented, structured patient history in plastic and aesthetic medicine is likely to lead to increased precision in diagnostics.

Moreover, the Axon solution increased the efficiency of patient service by reducing the HP's consultation time spent with the mapping of historical and actual health conditions. This enabled HPs to spend more time on high quality diagnoses and/or increase the number of serviced patients. These can be crucial during health crises as patient prioritisation can be built on comprehensive, available health data with the possible assistance from AI.

However, the adoption and implementation of Axon-like PEHR systems is not without challenges. Key concerns include data security, multi-platform data transfers and the need for an intuitive user-interface.

The potential for EHR technology in the framework suggested by Axon in plastic, reconstructive and aesthetic surgery is huge, considering that Axon's app stands out with its multi-featured capabilities and patient-focused approach, creating a collaborative environment between patients and plastic surgeons where informed personalised decision making and ultimately elevating the standards contributing to more successful and satisfying outcomes in plastic, reconstructive and aesthetic surgery.

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Data Availability Data and materials related to this study are available upon reasonable request.

Declarations

Consent to participate Informed consent was secured from all participants involved in the study.

Competing interests The authors declare no conflicts of interest or competing interests in relation to the Axon Dublin Study.

Ethical approval A local ethics committee was consulted and confirmed the research and publication is exempted. Axon Evolution confirms that the principles of the Helsinki declaration were followed for the research and publication of the Dublin Study.

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