Design and Implementation of a Secure Web-Based Healthcare Appointment Booking System

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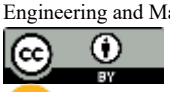

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***Abstract*—** Hospitals and patients benefit from accuracy and promptness in appointments, benefiting from both a measurable operational savings and a measurable patient savings. No shows are often as high as 20 to 30 per cent in outpatient facilities in India where scheduling is primarily done over the telephone, leading to wasted clinical time and patient not receiving care. This paper puts forward the design, implementation and empirical evaluation of MediGo an online secure healthcare appointment booking system for the use in medium sized clinics of India. The system has three user types: patient, physician and administrator, and provides all the necessary features for booking and/or managing appointments from end to end via a responsive PHP/MySQL web application. Regarding engineering aspect, some relevant features are: role based access control, automated SMS and e-mail reminder notify through cron scheduled jobs, secure storage of credential data in a bcrypt-hashed manner and parameterised SQL queries to nullify injection exploits. In a six-week controlled pilot in which 35 participants were held across two Greater Noida clinics, there was a 72% reduction in average "Booking Completion Time (from 11.7 minutes to 2.4 minutes), an 18 percentage drop in the number of bookings missed per week and a System Usability Scale (SUS) rating of 78.6 (grade: Good), with an additional 34% of all bookings made outside of regular clinic hours (which was not possible under the previous phone-only process). These findings validate the potential for significant scheduling gains using open-source Web technologies, without relying on health-IT proprietary solutions, in limited resource healthcare facilities. The work provides a blueprint for use of the reproducible implementation, an evaluation of the tool with market solutions, and options for the integration with Electronic Health Record (EHR) interoperability.

Keywords*—healthcare appointment scheduling; physician-patient portal; web-based health system; no-show mitigation; patient-centred care; PHP/MySQL; system usability; hospital management.*

I. INTRODUCTION

Patients in outpatient departments of Indian hospitals still have to jump through several hoops such as waiting in long phone queues, compromising with the timings of the department and in some cases having to make a personal visit just to arrange a consultation slot. Such friction, both expensive for patients and unproductive of clinical resources, is neither inevitable nor insurmountable. But still, most medium sized clinics in India are running through a very basic process of booking by phone, which has no self-service functionality, provides no scheduling data to analyse and offers no way to send reminders automatically [1].

The implications of this down stream are well known. In similar LMIH systems, the rate of no-shows in outpatient visits routinely ranges from 20- to 30%, with 1 in 3 to 5 patients who may have otherwise attended going missing from outpatient appointments or spots. Even months' scheduling delays add to the issue: The longer the time between the booking and consultation, the greater the chance of canceling or not attending [4]. These aren't just ancillary inefficiencies, but actually mean lost income, slower clinical activity, and postponed care for those in need.

Digital appointment systems present a structurally different kind of approach. Web-based portals solve the problem instead of just the symptoms by providing the following: remove dependence on Front Desk availability, allow 24-hours-a-day booking, and introduce a real time booking and slot availability view. The literature shows that when such systems have been implemented, there are measurable effects with reduced waiting time, reduction of the no-show rate, improvement in patient satisfaction and significant reduction in the number of works for the administration [3] [5]. Its advantages are carried over to users accessing the Web via a mobile device, particularly relevant in India where mobile penetration to the Web significantly exceeds desktop penetration, and a large number of users spend their daily time reach to the digital Web services through a mobile only.

This evidence still, however, has not been backed by any published literature on open-source self-hosted implementations, to sensibly assist small to medium sized Indian clinics. While there are large commercial platforms like Practo, Apollo 247 etc., there are certain complications with these such as subscriptions and vendor managed data storage limiting resource-poor medical facilities and raising concerns related to data-sovereignty which is becoming pertinent in the light of the introduction of the Digital Personal Data Protection Act 2023 [21] in India. A reproducible and open source version, with proven security characteristics and an empirical assessment, is, to the best of our knowledge, not available so far.

This paper fills this void. It introduces “MediGo”, a secure, open source, web-based booking portal, for use in mid-sized Indian clinics; as well as a report on the six-week “trial pilot” of the portal at two care partner sites in Greater Noida. Unique contributions of this paper are:

Documented complete system design (Requirements Elicitation, Database Schema, Application Architecture, and Security Implementation) which is detailed enough to be independently reproduced;

An empirical analysis of the deployed system comparing pre-deployment baselines in terms of booking completion time, missed-appointment rate and System Usability Scale (SUS) score; and

A cost comparative analysis of MediGo versus the relevant commercial scheduling solutions regarding cost, data-control, customisability and conformance to regulations;

Discussion on integration pathways towards achieving interoperability with EHR and Cloud migration roadmap.

The rest of this paper demonstrates the following. Section II reviews the literature and previous studies pertaining to appointment scheduling, patient portals and no-show reduction. The development methodology and system design is explained in section III. The results and analysis are given in Section IV. Conclusions and scope for future work are presented in section V.

II. RELATED WORK

A. Outpatient Scheduling Models and Waiting Time

Cayirli and Veral [9] present a comprehensive bibliography of the literature on outpatient scheduling, which lists the various pros and cons associated with the different models: block-appointment based and the individual-slot based.

While block models help decrease the wasted time of physicians, they focus the waiting of patients, while individual-slot models spread the waiting of patients more evenly. The variant called "open-access" where same day appointment are reserved for urgent cases has garnered press attention as a no-show mitigation strategy, although the sustainability of "open-access" services in lesser specialty practices has been challenged [10]. Ghazali et al. [16] found that waiting times which are not linked to clinical outcomes affect patient satisfaction, and as such can be used as a value measure of independent merit.

B. Digital Scheduling and Patient Portal Adoption

Patient portals in the form of web-based applications have become a major focus since their emergence in the mid-2000s, fueled by patient value incentives in the United States for the adoption of EHRs [7, 8], and a significant amount of evidence on the effectiveness patient portals has now accumulated. In a systematic review, Goldzweig et al. [5] found that portals were linked to greater adherence and satisfaction; however, they warned that effects were greatest for younger, more tech-savvy individuals. Iencchi et al. [13] claimed that the two most common barriers for adopting these were data-security concerns and a lack of digital literacy, while also a lack of on-boarding support. Tang et al. [11] reported an early example of an integrated e-health system that connected booking processes to the electronic medical records, with update based on this design pattern being industrialised in the subsequent commercial systems. In Primary Care, patient adoption of an e-appointment service was examined by Zhang et al. [1] - earlier convenience and belief in the service were the most significant predictors.

C. No-Show Mitigation through Digital Reminders

The relationship between appointment lead time and no-show probability is well understood: Wang and Gupta [4] model this relationship in an adaptive scheduling setting, and find that by keeping the salience of the next appointment in mind, reminder systems effectively decrease the lead time. An early web based triage and booking tool for sexual health clinics was found to have a positive impact on timely access (as shown by Jones et al. [2] and can be adapted to other high demand outpatient facilities). Automated digital reminders (SMS, e-mail, and push notifications) have been explicitly reported in various healthcare settings and demonstrated to lower no-show rates by 8–20 percentage points compared to a setting without any reminders [3]. As confirmed by Kumar and Sharma [18] post-pandemic India patients are much more receptive to digital health interactions than the survey results would otherwise have indicated, contributing to the rationale that such infrastructure investments are timely.

D. Indian Digital Health Context

Launched by the Government of India in 2022, Ayushman Bharat Digital Mission (ABDM) sets up a national digital health mission focused on unique health IDs, linked health records, and federated appointment booking [19]. ABDM is a long-term structural change but its infrastructure are not yet universally available to smaller clinics, especially outside Tier 1 cities. MediGo will be an originally standalone (with ABDM integration slated as a medium term roadmap item). E would comply with this requirement as mandated by the Digital Personal Data Protection Act 2023 [21] for any HAPD system, but also for any other system storing personal health-adjacent data, due to their data minimisation and purpose-limitation design". These requirements are specifically taken into account in E.

III. SYSTEM DESIGN AND METHODOLOGY

A. Requirements Elicitation

Semi-structured interviews with eight participants were completed at two clinics in Greater Noida, that included three administrative personnel at the front desk, three out-patient physicians (both general practitioner and internal medicine) and two patients who represented contrasting profiles of digital-literacy. Interviews were carried out at the end of three days with participants' consent, and then coded and analysed thematically. There were three high-priority, agreed-upon pain points within the roles:

- Delays in making appointments or rescheduling appointments that will not fit within business hours, leading to repeated caller back and/or lost patients;
- Lack of automated appointment reminder systems; patients often forgot to make appointments, which they made several days ahead of time, and there

were no plans in place on how to redistribute missed appointments; and

- Lack of real-time visibility of slot availability as patients had to go to the clinic, or put on hold while staff members looked through the paper registers.

Administrative personnel secondarily wanted a searchable, record-keeping system of appointments, a summary dashboard of the daily patient load at the clinic and flagging to identify regular no-show patients. Physician participants wanted a single daily glance of an advanced viewing screen with new patient and follow-up appointments separated.

B. System Architecture

MediGo follows a three layered architecture consisting of a presentation layer, application layer and data layer, all resident on a single virtualised server instance. The responsive HTML5/CSS3/JavaScript presentation layer is optimised for the 360 px wide screen that is the lowest available in the Android handset industry, thus ensuring the presentation can be seen on all of the lowest end Android handsets that the intended end users use. The application layer is written in PHP 8.1 and consists of application logic, business rules, PHP sessions, and outbound communication. Only one relational data source, a MySQL 8.0 database, is being used and that access is through PHP Data Objects (PDO) with named placeholders. The application is served using "Apache 2.4 and the mod rewrite rules provide clean urls and switch all traffic from http to https.

There are 3 authentication roles that manage access – Patients can book, view and cancel their appointments; Physicians can view their daily schedule, and records pertaining to patient appointments; Administrators can access the entire system, including patients, appointments and user management, and reporting dashboards. All role assignments are stored as User table and are checked at the application level during each user request.

C. Technology Stack

Table I summarises the technology choices and their functional rationale within the system.

TABLE I

TECHNOLOGY STACK AND FUNCTIONAL RATIONALE

Technology	Version	Role in System
HTML5 / CSS3	W3C Living Std.	Page structure; responsive layout (CSS Grid, Flexbox); semantic markup for accessibility
JavaScript (ES6+)	Browser-native	Client-side form validation; dynamic slot calendar via Fetch API; inline availability checks
PHP	8.1.x	Server-side routing, business logic, session management, SMTP relay, cron job execution
MySQL	8.0.x	Relational data storage; foreign-key constraints for referential integrity; six normalised tables
Apache	2.4.x	HTTP server; HTTPS enforcement; mod_rewrite clean URLs; .htaccess access control

D. Database Design

Relational schema has been normalised to third normal form (3NF). There are six main entities: User, Patient (extends User), Doctor (extends User), Department, Slot, Appointment, and Notification. The main entity is Appointment, which contains foreign-key relationships with Patient and Slot, thus resolving the many-to-many relationship. In any case, the Slot entity separates the physician's availability (represented by their common Schedule Templates) and the individual bookable slots, so that future versions can have automated slot generation without the schema updates.

The status of the visit is stored as an ENUM type in MySQL with the values scheduled, completed, cancelled and no-show. To ensure the requisite audit trail for operations reporting and regulatory compliance requirements rows are not hard-deleted

when they are cancelled, but rather soft-deleted (that is, their status is changed, but none of the rows are deleted). The Notification table tracks the reminder dispatched time, the delivery status, the mechanism/method (SMS or e-mail) that can be used to dispatch the reminder or notification, and scheduled dispatch time for each reminder event, facilitating automatic re-try logic and after-the-fact analysis of the effectiveness of a reminder.

E. Security Implementation

Security was considered a first-class design constraint, in a system that contains appointment details associated with identifiable people, it is not something that can be thrown in as an afterthought. The following control was used:

- Credential storage: bcrypt is used at cost factor 12, which makes it difficult to brute-force the credential database even after compromise of the same, with the ever enhancing hardware performance.
- SQL injection prevention: All database interaction is done with PDO prepared statements with named parameters. There is no user input that ending up being concatenated with other strings in the SQL query in the codebase.
- Cross site request forgery (CSRF): Synchroniser tokens are generated at user session level using a cryptographically random byte string (random_bytes(32)), and they are checked on the server-side before processing user request that may change state.
- Cross-site scripting (XSS): All user-supplied data rendered in HTML is passed through htmlspecialchars() with ENT_QUOTES. Content-Security-Policy and X-Frame-Options headers are set by Apache.
- Session security: sessions are secured with the help of HTTP-only, Secure, SameSite=Strict cookies. After 30 minutes of no activity, sessions will end.
- Transport layer: TLS 1.2 or later required, TLS 1.0 and below will be off in Apache configuration. No HSTS is enforced with a max-age of 1 year.
- DPDP Act 2023 Aligned – only those personal attributes that are strictly necessary for the appointment scheduling are collected such as Name, Contact Details, Appointment History. The contents of medical records are not stored. An account deletion feature enables patients to ask for their account's deletion.

F. Development Process and Testing

It was done using a five-iteration agile project management approach, taking fourteen weeks of development. A deployable build was generated from each iteration and was reviewed by a walk through session of two participant-observers from the interview cohort conducted for each iteration, which lasted one hour. It has been through feedback from these sessions that iterations to the slot-selection calendar (iteration 2), administrator-dashboard layout (iteration 3), and mobile-navigation menu (iteration 4) were made to refine them. All authentication, booking and cancelation logic was tested with PHPunit 10, with 87 tests and 214 assertions coming up to a line coverage of 91%. The entire booking process from picking the slot to final dispatch in the confirmation email was verified through integration tests. Upon completion of the user acceptance testing (UAT) with 10 users, three usability problems were identified and resolved: the date-picker labels were confusing, a confirmation screen was missing after cancelling and the wording of the error messages was inconsistent.

IV. RESULTS AND DISCUSSION

A. Pilot Setup

After initiating the solution, this 6-week pilot has been carried out during the fourth week at one partner clinic in Greater Noida. A total of 35 participants were recruited, including 21 patients, 8 doctors and 6 administrative staff members. The pre-pilot baseline data was gathered over the previous 4 weeks, obtained from the same clinic's booking register and on-site observation: 40 telephone bookings were timed on the spot using a stopwatch; there were few registers of bookings that were attended, or not attended, which allowed for few no-show rates to be calculated.

B. Quantitative Outcomes

Table II presents pre- and post-deployment measurements for the three primary metrics and two secondary metrics tracked throughout the pilot.

TABLE II

PRE- AND POST-DEPLOYMENT PERFORMANCE METRICS (N = 35, 6-WEEK PILOT)

Metric	Pre-Deployment	Post-Deployment	Change
Avg. booking completion time	11.7 min (SD 3.2)	2.4 min (SD 0.7)	−72.2%
Weekly no-show rate	17.3% of slots	9.1% of slots	−47.4% rel.
System Usability Scale (SUS)	N/A	78.6 / 100	Grade B
Admin time per booking	6.8 min (SD 1.4)	1.1 min (SD 0.4)	−83.8%
After-hours bookings	0% (impossible)	34% of total	+34 pp

The Booking completion time has been reduced to 72.2% due to the elimination of hold time, staff lookup time and manual register entry. Patients self report that anything between 2 and 6 minutes is acceptable for a routine transaction and the post deployment figure was 2.4 min which is similar to the benchmark data collected from comparable projects on self-service portals in tertiary-care settings [3]. As the standard deviation dropped from 3.2 to 0.7 minutes, this web-based pathway was not only faster overall, but "significantly more consistent" – which is an operationally important characteristic for staff running a high-volume clinic in schedule mode.

The reduction in the no-show rate was from 17.3% to 9.1%, a 47.4% relative improvement. This can be attributed to two system attributes that complement each other: sending automated reminders 48 hours and 2 hours ahead of the reminder date, and the fact that patients can cancel or reschedule through the system at any time, thus putting the process of "no show" to patients on the "action arm. A post-deployment rate of 9.1% is still high compared to the 5–7% rate found in some resource-rich settings, with more sophisticated reminder programmes [2]; there is still potential for further improvements with personalised reminder timing.

The SUS score is in the "Good" (70-84.9) threshold, which means that there is no significant investment required to onboard it to the population it serves. This is consistent with Carroll et al.'s [12] finding that on-boarding support is the biggest contributor to sustained portal engagement as the clinic printed a one-page printed guide and included a 10-minute walk-through for new users, which seems to have been enough to achieve the observed level of use".

Arguably the most strategically interesting result was that 34% of bookings happened outside of clinic hours, a finding that challenges the bounded nature of the baseline measurement methodology. With telephone only booking, no off hours booking is possible and the cost is not visible at all; with the portal, it is possible and it is duly reflected on the volume. This discovery is direct to the staffing choices of administration.

TABLE III

FEATURE COMPARISON: MEDIGO VS. COMMERCIAL ALTERNATIVES

Feature	MediGo	Practo Clinic	Generic HMS Module
Licensing model	Open-source (free)	SaaS subscription	One-time + AMC
Monthly cost (est.)	Server hosting only	INR 3,000–15,000+	Vendor-variable
Data hosting	Self-hosted (clinic)	Vendor cloud	Self/vendor
Source-code access	Full	None	Partial
EHR integration	Planned (FHIR)	Native	Varies
DPDP Act 2023	Designed-in	Vendor-managed	Varies
After-hours booking	Yes	Yes	Limited

Feature	MediGo	Practo Clinic	Generic HMS Module
Setup complexity	Moderate	Low (SaaS)	High

MediGo's key benefits versus both commercial options are: data sovereignty — you will be able to keep data on your own infrastructure with MediGo, and there wouldn't be a licensing cost. In turn, there is the increased complexity that accompanies setting up eHealth systems versus SaaS deployment and the lack of native EHR integration, which commercial systems tout as a key advantage. For any clinic with limited technology budgets and privacy concerns (such as data localisation), Medigo can be an interesting solution.

D. Qualitative Feedback

During the post pilot focus group, two common usability issues were identified. A primary need was from patients over 55 years of age that they were having some difficulty using the slot-selection calendar on small screen handsets, as they lack legibility and the ability to tap the desired slot. Second, “physician participants reported that the daily schedule view did not effectively differentiate between new patient and follow-up visits and they needed to click into each record before the visit in order to know the type of appointment. Both are not architectural concerns and can be solved by carefully designed interface iterations.

Administrative staff across the board said it had a definite impact on lessened cognitive load during the peak morning time, specifically because of a phone queue being eliminated and a dashboard bringing cancellations to light at the time of day they will happen. The current release also sees slot redistribution occur when there isn't a person present in the waiting room and no one has cancelled the slot, for the 34% of bookings that are online, thus eliminating the need for staff to moderate the process.

E. Limitations

These findings are limited in their generalisability in three ways. First, only 35 participants across six weeks in a single clinic were used for the pilot, a group size that was adequate to identify trends and patterns but that was not enough to make any inference to a population. The improvements in size need to be reported across three or more specialties and demographic clinics before it can be confidently stated how large it is. Second, the system has not yet been implemented with any EHR and physicians would have to access another system to obtain patient history, which was mentioned during the focus-group feedback and is a tangible "friction point" that the SUS score did not reflect. Finally, the paper fails to factor in that IT departments need to constantly backup, patch for security vulnerabilities, renew SSL certificates, and maintain the server, and many small clinics may not have the capacity to do it themselves.

V. CONCLUSION

In this paper, the authors have proposed a secure, open-source, web-based system - MediGo for healthcare appointment making to solve the problem of scheduling inefficiency in a medium scale healthcare system like clinics in India without any proprietary health-IT system. A 6 week controlled pilot resulted in consistent, measurable improvements in booking speed, missed appointments rates, and administrative workload as well as a good usability rating (according to the System Usability Scale) of the target user base. The results also suggest that one-third of all bookings take place outside clinic hours, providing insights and implications that go beyond usability and encompass clinic staffing models and patient access equity that are invisible to telephone-only booking systems.

Data sovereignty and regulatory compliance are intentionally created as central aspects of system design. MediGo is built to provide a trustworthy alternative to subscription-based platforms with data-residency and audit-access policies that can be opaque, ensuring that clinics' sensitive patient data is hosted on their own infrastructure with robust security measures in place”.

The contribution crystallizes around the concept of reproducibility: the code and implementation is sufficiently described so that any other clinic using PHP hosting could use a volunteer programmer to setup a technically similar system. The source codes and schema of the database are available by request from the corresponding authors.

Future research will focus on three things: making the effective "duct tape" integration with the HL7 FHIR compliant EHR systems; choosing a managed Indian cloud server setup to prevent burden on small clinics for server maintenance; and implementing a predictive no-show model using the appointment lead time, specialization, and patient-attendance history to personalize reminder schedule and overbookings. To determine generalisability of the pilot findings reported here, evaluations should be conducted in wider clinic contexts and through a longer time period (at least three months).

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REFERENCES

[1] X. Zhang, P. Yu, and J. Yan, "Patients' adoption of the e-appointment scheduling service: A case study in primary healthcare," Studies in Health Technology and Informatics, vol. 204, pp. 176–181, 2014.

[2] R. Jones, A. Menon-Johansson, A. M. Waters, and A. K. Sullivan, "eTriage – A novel web-based triage and booking service: Enabling timely access to sexual health clinics," International Journal of STD & AIDS, vol. 21, no. 1, pp. 30–33, 2010.

[3] "Online scheduling applications may improve customer satisfaction, but setup is not always easy," Internet Healthcare Strategies, vol. 6, no. 5, pp. 1–5, 2004.

[4] W. Wang and D. Gupta, "Adaptive appointment systems with patient preferences," Manufacturing & Service Operations Management, vol. 13, no. 3, pp. 373–389, 2011.

[5] C. L. Goldzweig et al., "Electronic patient portals: Evidence on health outcomes, satisfaction, efficiency, and attitudes – A systematic review," Annals of Internal Medicine, vol. 159, no. 10, pp. 677–687, 2013.

[6] HealthIT.gov, "What is a patient portal?" [Online]. Available: https://www.healthit.gov/providersprofessionals/faqs/what-patient-portal. Accessed: Sept. 26, 2016.

[7] HealthIT.gov, "Meaningful use: Definition and objectives," [Online]. Available: https://www.healthit.gov. Accessed: Oct. 3, 2016.

[8] HIMSS, "Using patient portals to achieve Meaningful Use Stage 2," [Online]. Available: http://www.himss.org. Accessed: Oct. 3, 2016.

[9] T. Cayirli and E. Veral, "Outpatient scheduling in healthcare: A review of literature," Production and Operations Management, vol. 12, no. 4, pp. 519–549, 2003.

[10] D. Gupta and B. Denton, "Appointment scheduling in healthcare: Challenges and opportunities," IIE Transactions, vol. 40, no. 9, pp. 800–819, 2008.

[11] P. C. Tang et al., "PAMFOnline: Integrating eHealth with an electronic medical record system," AMIA Annual Symposium Proceedings, pp. 644–648, 2003.

[12] J. K. Carroll et al., "Barriers and facilitators to the use of patient portals: A systematic review of the literature," Journal of General Internal Medicine, vol. 34, no. 10, pp. 2437–2446, 2019.

[13] F. Parwej, N. Akhtar, and Y. Perwej, "An empirical analysis of Web of Things (WoT)," International Journal of Advanced Research in Computer Science, vol. 10, no. 3, pp. 32–40, May 2019.

[14] Y. Perwej, F. Parwej, and N. Akhtar, "An intelligent cardiac ailment prediction using efficient ROCK algorithm and K-Means & C4.5 algorithm," European Journal of Engineering Research and Science, vol. 3, no. 12, pp. 126–134, Dec. 2018.

[15] N. R. Armfield, M. Bradford, and N. K. Bradford, "The clinical use of Skype: For which patients, with which problems, and in which settings? A snapshot review," International

Journal of Medical Informatics, vol. 84, pp. 737–742, 2015.

[16] M. R. J. D. M. Ghazali et al., "Hospital waiting time: The forgotten premise of healthcare service delivery?" International Journal of Health Care Quality Assurance, vol. 24, no. 7, pp. 506–522, 2011.

[17] O. Stan, C. Avram, I. Stefan, and A. Astilean, "Integrated innovative solutions to improve healthcare scheduling," in Proc. IEEE Int. Conf. Automation Quality and Testing Robotics (AQTR), pp. 1–6, 2016.

[18] S. Kumar and R. Sharma, "Adoption of digital health platforms in post-pandemic India: An exploratory study," Journal of Health Informatics in Developing Countries, vol. 16, no. 2, pp. 1–14, 2022.

[19] Ministry of Health & Family Welfare, Government of India, Ayushman Bharat Digital Mission – Operational Guidelines, New Delhi, 2022.

[20] P. Samoilov, D. Karimanzira, and T. Runkler, "Predictive modelling of patient no-shows in outpatient scheduling using machine learning," BMC Medical Informatics and Decision Making, vol. 22, pp. 1–13, 2022.

[21] Ministry of Electronics & Information Technology, Government of India, Digital Personal Data Protection Act 2023, Gazette of India, No. 60, Aug. 2023.