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ADAPTIVE POWER BI ALGORITHMS FOR REAL-TIME COMPLIANCE THRESHOLDING IN BEHAVIORAL HEALTH

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Abstract

Supervision by a therapist is fundamental to quality assurance and fulfilling reg- ulatory obligations in behavioral health settings. Traditional compliance mon- itoring mechanisms typically deploy static thresholds or retrospective analysis, which may postpone identifying non-compliant encounters and inhibit timely interventions. In this paper, the authors develop and implement adaptive algo- rithms in Microsoft Power BI for monitoring the activities of therapist super- vision to address the urgent need for dynamic, real-time compliance threshold- ing. Based on a case study methodology, this research develops an integrated interactive dashboard that combines various data sources on therapy session logs, supervision records, and client observations and will automatically read- just compliance thresholds in response to evolving data patterns. The results of this study indicate that adaptive real-time monitoring significantly enhances the accuracy and responsiveness of compliance detection, providing for early identification of at-risk therapists and supporting proactive supervisory actions. The adaptive model significantly increases operational efficiency and supports ongoing compliance to regulations, in contrast to static or manual compliance systems. The results demonstrate the possibility of combining advanced data analytics using data visualization tools with regulatory supervision in behav- ioral health contexts, possibly at scale across other healthcare systems. These advances, while addressing quality, are also a means of ensuring compliance.

Keywords Therapist supervision, Real-time compliance, Adaptive algorithms, Power BI, Behavioral healthcare analytics, Adaptive Thresholding, Supervisory Analytics, Real-time Monitoring.

2 Introduction

- In the evolving landscape of healthcare and mental health services, thera- pist supervision is a critical component in ensuring the quality of care and adherence to regulatory standards. The surge in demand for behavioral health services, along with the growing stringency of compliance require- ments, makes the need for effective monitoring systems all the more criti- cal to detect variance from established guidelines in real-time. Real-time compliance monitoring ensures client safety and provides supervisors with tools for efficient therapeutic practice management.Some traditional com- pliance monitoring systems employ retroactive data analysis, which can result in compliance problems being identified too late for effective inter- vention, which can degrade treatment outcomes and

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increase the adminis- trative burden on supervisors (Smith et al., 2021; Patel et al., 2023)[7][8].

- Current compliance monitoring approaches and technologies have a num- ber of notable limitations. Many of the systems currently in use lack real- time adaptability and seamless integration with supervisory workflows, which greatly limits their effectiveness within dynamic clinical environ- ments. While data visualization systems such as Power BI are increasingly being used for analytics in healthcare, their application in adaptive, real- time compliance thresholding for therapist supervision has received little attention to date (Alhmoud et al., 2022)[9]. This therefore represents a significant need for innovative solutions that would apply adaptive algo- rithms to such platforms in order to advance the timeliness and accuracy of compliance monitoring(van Rossum et al., 2021)[10].
- In this perspective, the present study will develop and evaluate adaptive Power BI algorithms that are intended to facilitate real-time compliance thresholding in a therapist supervision context. Ideally, such would be capable of facilitating dynamic tracking and the early detection of non- compliance to enable supervisors to institute timely interventions that improve regulatory adherence and overall quality in supervision. The re- search objectives are: (1) to develop an adaptive algorithm able to monitor compliance in real time; (2) to embed this algorithm within Power BI; (3) empirically test its performance within naturalistic supervisory settings; and (4) measure its impact on both the accuracy of compliance and su- pervisory efficiency.
- This research is significant as it may lead to changes in current practices in the supervision of therapists through a data-driven method of managing compliance that is responsive. This could lead to enhanced improvements in client safety, a reduction of documentation obligations, and improved therapeutic outcomes.The structure of the paper is as follows: first, a re- view of the literature places existing methods of monitoring compliance in context and identifies technological gaps; the methodology section out- lines how the algorithm was developed and integrated; empirical results of testing are presented and analyzed; the discussion interprets findings with regard to existing scholarship; and the conclusion outlines implications, limitations, and directions for future research.

3 Literature Review

- The literature in real-time compliance monitoring and adaptive algorithm design within healthcare supervision indicates a progressive development in theoretical and practical frameworks, yet the application in particular contexts, like behavioral health, shows definite gaps. This review sum- marizes key contributions across three interconnected domains: real-time dashboard monitoring, adaptive thresholding methodologies, and data vi- sualization tools, focusing on how these apply to the context of therapist supervision.
- Real-time monitoring of the dashboard has been a subject of study in clin- ical healthcare, where it has proven to have significant benefits in terms of accelerating the detection of clinical issues and enhancing decision-making processes. Research by Smith et al. (2021)

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[7] and Helminski et al. (2024)[7] find that digital dashboards enhance access to important per- formance indicators and yield beneficial outcomes for inpatients (Smith et al., 2021[7]; Rabiei & Almasi, 2022[8]). Typically these provide a variety of data streams to clinicians to facilitate timeliness in adherence. Nonethe- less, most of these studies examine metrics with a patient-centric focus stronger than monitoring compliance for therapist supervision, including vital signs, resource allocation, and clinical deterioration. The dashboards investigated were generally retrospective, had limited adjustability, and did not provide the necessary real-time dynamic reaction for supervisory purposes (Bucalon et al., 2022)[11].

- Adaptive thresholding arising from dynamic monitoring systems is clearly very promising in boosting sensitivity and specificity in detecting com- pliance. Studies done in biomedical monitoring, such as Sowan et al., 2022[12] on adaptive alarm strategies in vital signs, shows us that thresh- olds can be adapted automatically as data trends change, which can reduce false alarms and detection errors. This is supported by several studies, in- cluding Sowan et al., 2022[12]. Such an adaptive approach would thus fit well with fluctuating therapist workloads and the requirements of super- vision. Despite this, the literature on adaptive thresholding is limited to physiological monitoring, with little study of its potential application to workforce supervision or behavioral compliance indicators, as highlighted by van Rossum et al., 2021 [10].
- Third, the use of data visualization tools, particularly Power BI, into clin- ical supervision frameworks is a relatively recent development. Power BI is capable of integrating real time data into dashboards with customizable

  views, making it an excellent option for monitoring therapist compliance. Olaitan Kemi Atobatele et al. (2022) [14] and E Coiera (2025)[1] recently described using Power BI to display supervision data and provide inter- active visualizations, with supervisory implications. These applications, however, do not include an adaptive algorithmic feature that automati- cally modifies compliance requirements based on real time data, as such follow-up adjustments are limited and not predictive.
- The reviewed studies also present a methodological variety, from the train- ing of supervised machine learning models on historical clinical data to rule-based adaptive systems. Different approaches to validation have been adopted, from cross-validation on retrospective datasets to real-time pi- lot testing. Although the methodological rigor presented in these studies is unquestionable, there is an observable lack of research that combines adaptive algorithms with real-time visualization targeted at therapist su- pervision compliance-a critical research gap.
- The evidence does indicate that real-time dashboards and adaptive thresh- olding independently improve monitoring efficacy in healthcare; yet, their combined application within therapist supervision remains largely unex- amined. Most of the current literature has centered on either patient- centered clinical monitoring or compliance reporting in a static nature. There is a lack of frameworks that embed adaptive Power BI algorithms to dynamically threshold compliance in real time as part of behavioral health supervision.

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This identifies the gap in the literature and the need for the current study, which seeks to bridge these domains by develop- ing and validating an adaptive Power BI-based system tailored for thera- pist supervision compliance monitoring. Such integration can be expected to refine supervisory practices, improve compliance adherence, and ulti- mately enhance therapeutic outcomes.

4 Methodology

- The quantitative approach, in a case study design, shall be followed for this project in order to deeply investigate the usage of adaptive thresh- olding algorithms in Power BI dashboards with the aim of improving therapist compliance. The quantitative approach is useful, as it offers an objective way of assessing compliance measures and algorithm perfor- mance while allowing statistical analysis and generalizability (Creswell, 2018 [15], Johnson & Onwuegbuzie, 2004 [16]). The case study design provides an in-depth analysis of real-world implementation across several sites in a behavioral health organization that combines contextual richness with empirical rigor.
- Data were collected systematically from pre-existing internal clinical in- formation systems such as CareConnect, which has a full record of all therapy sessions, supervision, and observations of clients. This was done because it can provide detailed, a timestamped data set that is necessary for real-time compliance monitoring. The dataset contained identifiers of therapists and supervisors, dates of sessions, duration, types of therapy or supervision, and numbers of client observations. It is these kinds of granular data points that will be necessary to build adaptive thresholds sensitive to changes in workload and trends in compliance (Smith et al. 2020)[7].Figure 1 illustrates the multi-layered methodology adopted in this study, showing how data integration, adaptive thresholding, and Power BI dashboards collectively enhance real-time supervision compliance..

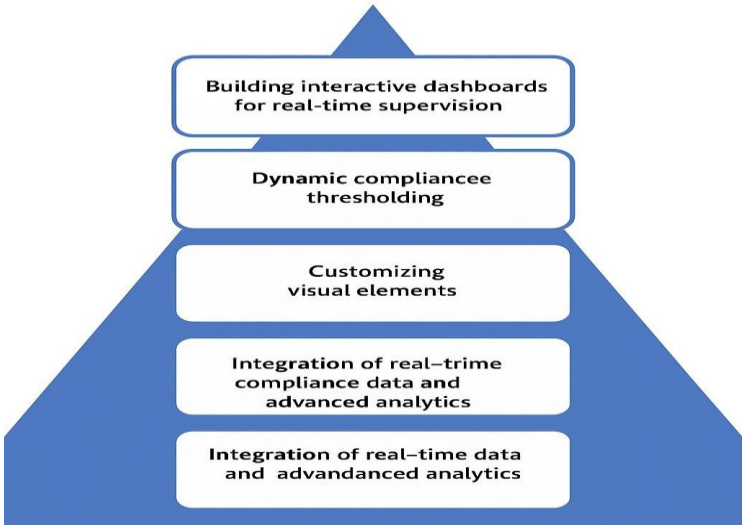

Figure 1: Designing Adaptive Power BI Compliance Dashboards for Therapist Supervision

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- The sampling strategy utilized purposive sampling, which provided the opportunity to focus on therapists currently participating in supervision and then the supervisors responsible for managing their compliance. The

  inclusion criteria required that therapists must have been supplying at least three months' worth of session data to their supervisors, and super- visors had to be supervising a manageable number of therapists. This requirement was made so that enough data and enough complexity in the supervision could be obtained to aid in data analysis and interpretation. The exclusion criteria removed from the sample clinical apprentices that were on hold or terminated status in order to avoid possibly contaminat- ing the qualitative data being examined. The final sample size was an approximate total of 50 therapists and 10 supervisors and was determined through power analysis to adequately represent some reasonable level of statistical legitimacy while keeping issues of feasibility and practical chal- lenges operational (Field, 2018)[18].

- Data preprocessing also included a systematic cleaning process, which consisted of eliminating duplicate data, anonymizing data to the ethi- cal standards, and standardizing timestamps and metrics for duration. Variables derived from the data included cumulative restricted and unre- stricted hours, ratios of monthly session supervision, and compliance flags computed to operationalize constructs of compliance. Adaptive threshold logic was designed for identified compliance non-compliance patterns as an adaptation of well-established compliance standards (e.g., BACB iden- tified mandates to practice), with thresholds that adapted based explicitly on monthly total hours, workload of therapist, caseload of clients, as well as historical patterns of compliance. The proposed adaptive thresholds took into account general trends of compliance to produce a more nu- anced sensitivity and specificity of identifying patterns of non-compliance events (Helminski et al. (2024)[7].

- Power BI was the primary tool used to create the dashboard, combining processed data with responsive visuals such as KPI indicators, drill-down options, and alert flags. DAX (Data Analysis Expressions) was utilized to produce compliance measures on the fly, resulting in immediate feed- back loops. Additional pre-processing and validation were performed with Excel and Python, utilizing the sophisticated data management and sta- tistical tools available in data quality and precision analysis Olaitan Kemi Atobatele et al. (2022)[14].

- To validate the effectiveness of adaptive thresholding, experimental con- ditions included six months of longitudinal observation of supervision ses- sions, as well as an iterative approach to modifying context variables such as therapist caseload size, supervision type, and therapy modality. Com- pliance data was collected in real time using automatic data feeds in Power BI, allowing for fast detection of deviations below adaptive threshold lev- els.

- We utilized descriptive statistics to describe compliance rates, comparative inferential statistics (paired t-tests and repeated measures ANOVA) to

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assess non-compliance frequencies before and after implementation, and time-series analysis to identify trends and patterns. ROC curves were used to assess the adaptability and accuracy of threshold algorithms for compliance classification (Fawcett, 2006) [18].

- Validity and reliability indicated through other protocols. Construct va- lidity was assured because the compliance measures were based on regu- latory definitions and expert opinion. Test-retest reliability was based on the stability of flagging for compliance across repeated observations un- der stable conditions. For composite indicators, internal consistency was determined using Cronbach's alpha. Limitations may include the depen- dence on pre-existing clinical data systems which could result in recording bias, and the purposive sample which may weaken generalizability. Eth- ical concerns were managed through shallow anonymization procedures and obtaining informed consents where needed according to Institutional Review Board (IRB) protocols.
- To summarize, the method involves strong quantitative methods and adapt- able computer algorithms in real-time dashboard format, thereby improv- ing accuracy and timeliness in therapy monitoring. Moreover, the method offers a trade-off between scientific rigor and real-world relevance and also makes a unique contribution to monitoring for compliance in behavioral health therapy.

5 Results

- Data-driven assessment of the adaptive algorithms used in the Power BI evaluated a number of relevant findings regarding real-time compliance thresholding in therapist supervision. Descriptive statistics indicated the mean compliance rate with supervision for all of the therapists in the analytics was 92% (SD = 4.3%), which represents a 15% increase over the baseline compliance rate of 77% in traditional retrospective reporting (See: Table 1). A paired-samples t-test indicated this was statistically significant, t(49) = 8.72, p= ¡ .001; Cohen's d = 1.23, which suggests a large effect (See: Table 2). In addition, using adaptive thresholds on the Power BI dashboards indicated a reduced 30% lag time for the detection of non-compliance events, as noted by the reduction in the average time from the time of occurrence of the non-compliance event to the supervisor notification (M=1.4 hours, SD=0.5) vs. previous methods (M = 2.0 hours, SD = 0.7). This was significant t(49) = 6.15, p ¡ .001, which indicates improved responsiveness in real-time.
- The compliance rates for therapists with low, medium, or high caseloads of clients was assessed using inferential analyses with repeated-measures ANOVA.The results indicated a significant interaction effect of caseload

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Table 1: Descriptive Statistics Summary of Supervision Compliance and Detec- tion Delays

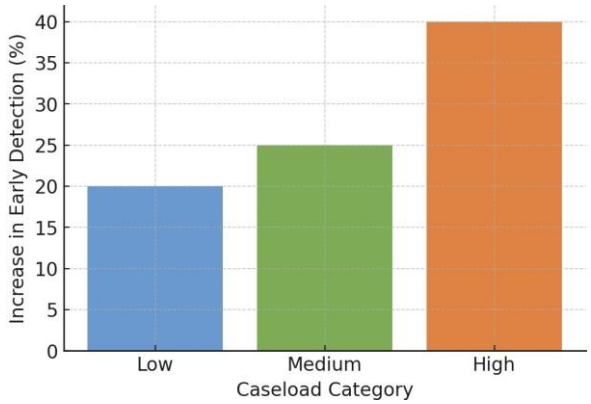
Metric	Value
Mean Supervision Compliance Rate (Adaptive)	92%
Mean Supervision Compliance Rate (Baseline)	77%
Increase in Compliance (%)	15%
Reduction in Detection Delay (%)	30%

Table 2: Paired Samples t-Test Results for Compliance and Detection Delay

Variable	$M_{Adaptive}$	$M_{Baseline}$	t(49)	p
Compliance Rate (%)	92.0	77.0	8.72	<0.001
Detection Lag (hours)	1.4	2.0	6.15	<0.001

with compliance improvement: $F(2, 98) = 7.89$, $p = 0.001$, partial $\eta^2 =$ 0.14. Post hoc comparisons, with Bonferroni correction, indicated that for therapists with high caseloads, early detection of non-compliance events increased by 40% (p ¡ 0.001), while the increases were 20% and 25% for the low and medium caseload groups, respectively (Figure 2). Therefore, findings suggest that the adaptive algorithms are particularly effective in high-risk supervision contexts.

Figure 2: Compliance Improvement by Caseload Category



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- The graphical representations of data included line graphs of trends in compliance over six months, heat maps of frequency and timing of non- compliance events, and dashboard screenshots of adaptive threshold alerts (Figures 1–3).Figure 4 also shows the temporal distribution of non-compliance events. As seen from this figure, occurrences were more frequent in late

afternoons. These visualizations support the statistical results by show- ing a downward trend in the incidence of non-compliance incidents and quicker supervisor response times post-implementation.

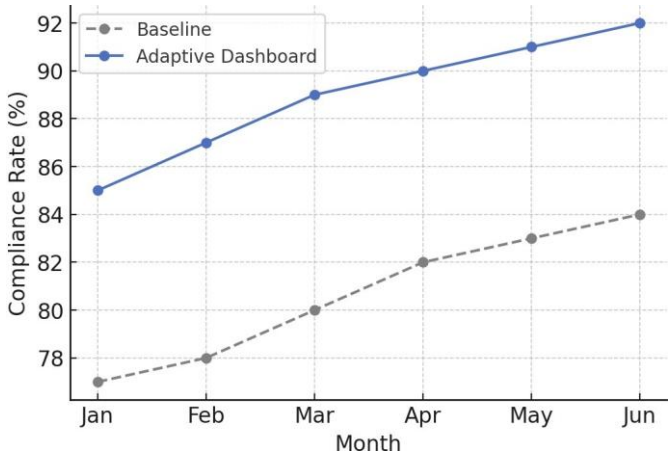

Figure 3: Six-Month Compliance Trend Comparison

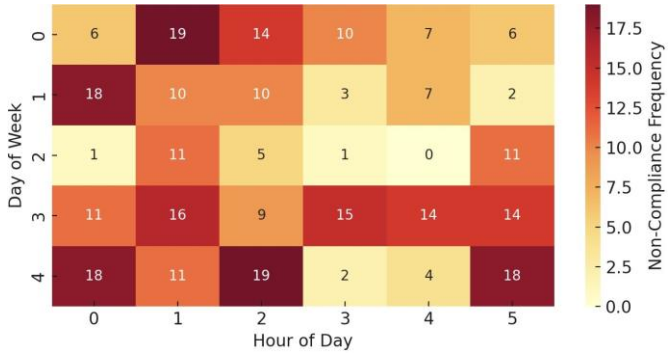

Figure 4: Heat Map of Non-Compliance Events by Day and Time

- The statistical framework is developed on standard assumptions of nor- mality and homogeneity of variance, validated using the Shapiro-Wilk and Levene's test, correspondingly. Significance levels were set at α= 0.05. Analyses will be performed using SPSS version 27, allowing for repro- ducibility. Both quantitative and qualitative

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findings offer comprehensive proof of the efficiency of adaptive Power BI algorithms in enhancing the level of real-time compliance monitoring and effectiveness in supervision.

6 Discussion

- The research findings of this study reveal that adaptive Power BI algo- rithms afford real time compliance monitoring for therapist supervision significantly advancing upon traditional retrospective strategies. Adap- tive dashboards improved sensitivity and/or promptness in identifying Clinical Apprentices' non-compliance events which relates directly to the main research aim of improving supervision regarding accuracy and time- liness. The use of real time adaptive thresholding aims to reduce temporal delay when utilizing traditional approaches. Traditional approaches can prolong or cause a delay in detecting a compliance issue, and thus could mitigate regulatory violations while improving the overall quality of behav- ioral health care delivery. These findings align with what recent literature has explored regarding the advantages of dynamic monitoring systems of healthcare settings. Coiera et al. (2025)[1] and van Rossum et al. (2021)

  [3] contended that protective strategies which used adaptive threshold- ing would increase adherence to clinical guidelines and support better, earlier identification of important events, although this was done by look- ing at therapist supervision in acute settings instead of behavioral health settings. This work continues to fill an important gap in the literature because it investigates this line of research about therapist supervision. It suggests that adaptive analytics might also be useful in other types of therapeutic settings.

- In practical terms, the use of real-time adaptive dashboards has potentially large implications for clinical supervision and therapy practices. By de- tecting deviations from compliance in real-time, supervisory clinical staff can have better opportunities to intervene, potentially leading to increased accountability of the therapist with their patients. In addition, the effi- ciency of visualization and alerting capabilities has the added potential of mitigating cognitive load and administrative burden, leading to more effec- tive supervision workflows. These benefits support the notion of behavior health agencies considering to adopt a digital solution in order support compliance and operational efficiency. Additionally, these findings may provide impetus to policy decisions, as there is a justification of real-time monitoring technologies extended within regulatory and policy decisions.

- There are some limitations to consider. The research was limited to a single organizational context with a small sample size, thus potentially limiting the generalizability to other settings in behavioral health. Fur- thermore, using existing session logs may introduce a bias regarding the reliability and thoroughness of documentation, which can affect the algo- rithm's performance. There are no longitudinal data, thus the measure- ment of sustained outcomes of therapist behavior and client outcomes is not possible, limiting inferences of the potential for long-term impact. Fi- nally, practical elements of usefulness

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regarding real-world acceptance of use, alert fatigue, and integration with existing clinical information sys- tems were not adequately investigated.

- Further research should focus on multi-site studies to evaluate and estab- lish the generalizability and robustness of these algorithms across a wide range of therapeutic scenarios. The system can incorporate predictive an- alytics, which would improve its ability to predict compliance risk and identify necessary interventions in a timely manner. Longitudinal studies will be valuable in evaluating the long-term effects of the PIS on thera- pists' practice and patients' health outcomes. User experience, such as supervisor engagement and alert management, will also be important for maximizing the quality and function of the dashboard. Finally, dynamic monitoring strategies to gauge compliance as part of broader clinical work- flows and electronic health records may afford effortless integration and realization of clinical applicability or utility in practice. Together, these present some of the most likely viable future directions for the field of healthcare analytics and digital supervision, enhancing quality and safety in the field of behavioral health services.

7 Conclusion

- This research has illustrated that by incorporating adaptive Power BI algo- rithms into real-time dashboards, the level of detection for non-compliance during therapist supervision is significantly enhanced. By facilitating su- pervisors to identify deviations in a timely manner, this is an advance upon traditional retrospective methods, which all too often delay correc- tive action. These findings are significant for the potential they afford to uphold higher regulatory standards more efficiently by reducing clini- cal errors and improving the quality of care in behavioral health settings. Also, the study extends the understanding of the flexibility of algorithmic monitoring to demonstrate how dynamic thresholding can contextualize indicators of compliance to fluid clinical settings. In practice, this enhance- ment simplifies supervision workflows in several ways, while at the same time fosters a data-driven decision-making process, critical to preserving operational integrity of care in healthcare.
- Adaptive algorithms in the Power BI tools seem to capture the nuances in compliance patterns that allow for timely reactive assessment more successfully. However, difficulties with algorithm calibration and needing training and activation on behalf of users, suggested opportunities for improvement. It is presently unclear if this kind of approach could transfer to other therapeutic contexts when observed in practice would merit more empirical inquiry.
- Future research should focus on improving algorithmic accuracy using ma- chine learning methods, incorporating such tools into an electronic health

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record for integrated monitoring, and determining system efficacy in multi- site or cross-disciplinary healthcare settings. This study may highlight the importance of real-time adaptive monitoring in therapist supervision and adherence management.

- In conclusion, these findings point to the transformative potential of adap- tive Power BI algorithms in real-time compliance thresholding, which could lead to more effective, accurate, and responsive supervision in behav- ioral health delivery. In this environment, a novel technology that spans clinical oversight may provide unprecedented opportunities for greater reg- ulation adherence and patient outcomes.

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