Applications of Artificial Intelligence in Predicting and Managing Antimicrobial Resistance: A Systematic Review



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Roll no.-PG/24/011

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Mentor Approval

SS

Sumant Swain

To: Anchal Kalia

Dear Anchal

Your PPT has been approved for the presentation. All the best.

Best

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Introduction (1/2)

What is Antimicrobial Resistance (AMR)?

- AMR occurs when bacteria, viruses, fungi or parasites evolve mechanisms that render antimicrobial agents ineffective
- Results in: untreatable infections, prolonged hospitalisation, increased mortality and rising healthcare costs
- WHO identifies AMR as one of the top 10 global public health threats

Global Burden

- 1.27 million deaths directly attributable to AMR globally in 2019 Global Research on Antimicrobial Resistance (GRAM Project)
- 4.95 million deaths annually associated with AMR-related conditions
- India has some of the highest AMR rates in the world — over 60% of K. pneumoniae resistant to common antibiotics
- ESKAPE pathogens: E. faecium, S. aureus, K. pneumoniae, A. baumannii, P. aeruginosa, Enterobacter spp. — most dangerous MDR organisms

Objectives of the Study

Primary Objective

- To systematically review the role of Artificial Intelligence in predicting and managing antimicrobial resistance

Secondary Objectives

- To identify and classify AI techniques used in AMR research by application domain and algorithm type
- To evaluate the effectiveness of AI models in predicting resistance patterns (AUC, sensitivity, specificity, accuracy)
- To assess the role of AI in antibiotic stewardship programs (ASP) and clinical decision-making
- To identify implementation challenges, ethical considerations, and evidence gaps relevant to Indian healthcare settings

Research Questions

- How is AI being used in AMR detection and prediction?
- Which AI technique is most commonly used and most effective?
- What is AI's role in antibiotic stewardship and clinical decision-making?

Methodology (1/2)

Study Design

- Systematic Review conducted in accordance with PRISMA 2020 guidelines
- Secondary research — synthesis of existing peer-reviewed literature

PICOS Framework

- P (Population): Peer-reviewed studies on AI in AMR (2017–2026)
- I (Intervention): Machine Learning (ML),Deep learning(DL), Natural language Processing (NLP),Reinforcement Learning (RL) techniques applied to AMR
- C (Comparator): Different AI algorithms; AI vs conventional AST
- O (Outcome): AUC, accuracy, sensitivity, specificity, DOT reduction, hit rates
- S (Study Design): Original research, systematic reviews, meta-analyses — English, peer-reviewed

Search Strategy

- Databases: PubMed · Google Scholar · Scopus · ScienceDirect · Springer · Web of Science
- Boolean: ("Antimicrobial resistance" OR "AMR") AND ("Artificial intelligence" OR "Machine learning" OR "Deep learning")
- Language: English only

Methodology (2/2)

Inclusion Criteria

- Published 2017–2026; peer-reviewed original research, systematic reviews, meta-analyses
- Studies evaluating AI/ML applied to AMR prediction, detection, surveillance, drug discovery, or stewardship
- Studies involving bacterial pathogens; reporting AUC, accuracy, or clinical outcome metrics
- English language publications only

Exclusion Criteria

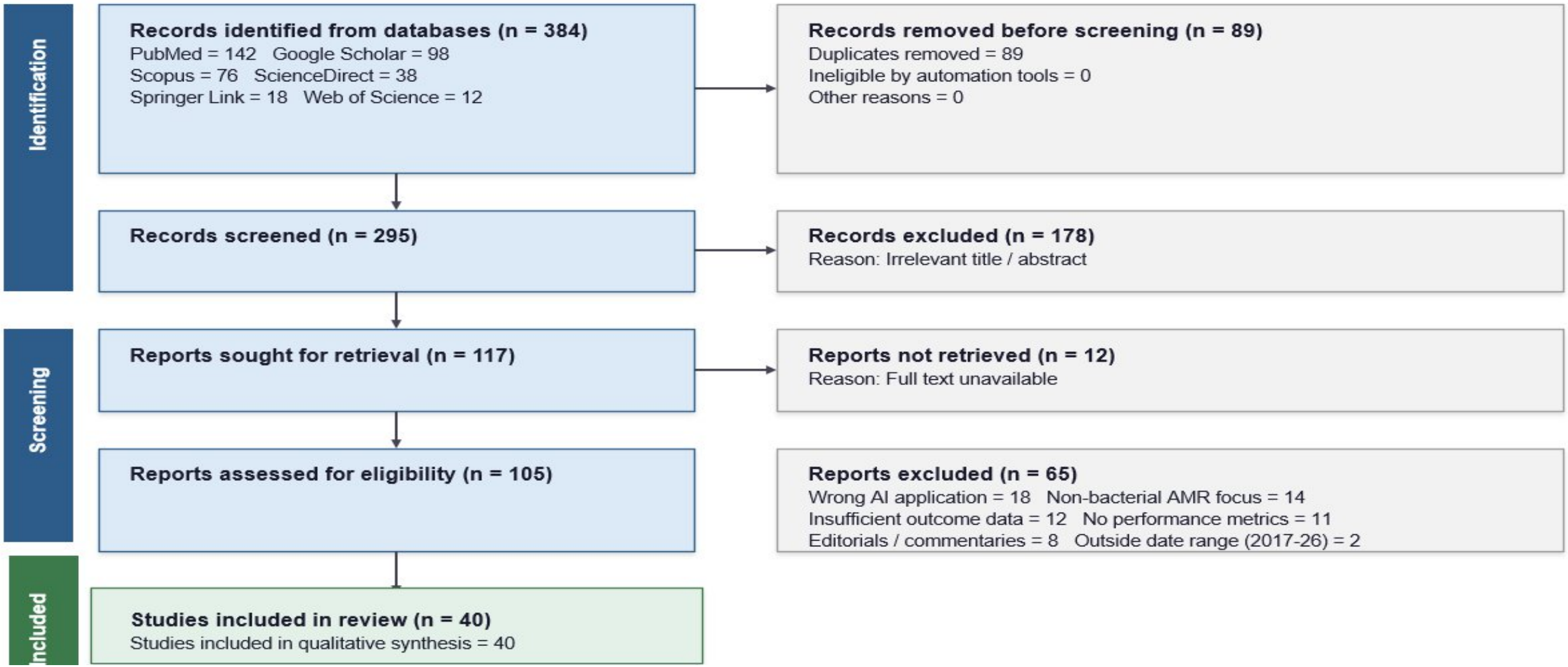
- Conference abstracts, editorials, opinions without original data
- Purely in silico or animal-only studies; duplicate populations

Quality Assessment — CASP Checklist

- Critical Appraisal Skills Programme (CASP) applied to all 40 included studies
- Three bias domains assessed: Selection Bias · Measurement Bias · Reporting Bias
- Ratings: Low (≥7/10 criteria) | Moderate (5–6/10) | High (<5/10)
- Result: 31/40 studies (77.5%) rated Low overall risk of bias

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PRISMA 2020 Flow Diagram



Results (2/3) — Study Characteristics

Distribution of 40 Studies by Thematic Domain

- Domain 1 — AI for AMR Prediction (Genomic ML): n = 16 studies | AUC range: 0.85–0.97
- Domain 2 — AI-Based Clinical Decision Support (CDSS): n = 8 studies | AUC range: 0.85–0.92
- Domain 3 — AI in Novel Antibiotic Drug Discovery: n = 7 studies | Hit rate: 41–100%
- Domain 4 — AI for AMR Surveillance: n = 5 studies | Outbreak lead time: 4–6 weeks earlier
- Domain 5 — AI in Antimicrobial Stewardship Programs: n = 4 studies | Pooled AUC: 0.89

AI Algorithm Frequency

- Random Forest: n = 19 studies (47.5%) — Most commonly used and highest-performing
- XGBoost / LightGBM: n = 12 studies (30.0%) — Best for EHR-based stewardship
- Support Vector Machine (SVM): n = 11 studies (27.5%)
- Deep Neural Networks (CNN, RNN, Transformer): n = 14 studies (35.0%)
- MALDI-TOF + ML hybrid: n = 4 studies | NLP-based models: n = 6 studies
- Reinforcement Learning / Generative AI: n = 2 studies (ApexAmphion — 100% hit rate)
- Explainable AI (SHAP-based XAI): incorporated in n = 5 studies

Results (3/3) — Performance Metrics

Performance Metrics by AI Technique

- Random Forest (n=19): AUC 0.87–0.97 | Accuracy 87–93% | Top performer across AMR domains
- XGBoost / LightGBM (n=12): AUC 0.87–0.95 | Accuracy 86–92% | Efficient for clinical EHR data
- Support Vector Machine (n=11): AUC 0.85–0.93 | Accuracy 82–91%
- Deep Neural Networks (n=14): AUC 0.88–0.97 | Accuracy >95% for image-based AI (Gram stain)
- MALDI-TOF + ML hybrid (n=4): AUC 0.85–0.91 | Accuracy 87–90%
- NLP-Based Models (n=6): Accuracy 83–91% | AMR trend detection 4–6 weeks earlier
- RL / Generative AI (n=2): 41–100% in vitro hit rates (ApexAmphion: 100%)

Pathogen Coverage

- K. pneumoniae (n=14) · E. coli (n=13) · MRSA (n=10) · P. aeruginosa (n=9) · MDR-TB (n=6)

Discussion (1/2)

- WGS + RF/XGBoost achieves AUC 0.87–0.97 for priority pathogen-antibiotic combinations
- Integrating WGS with AST data improves performance — hybrid data pipelines are the standard
- AI models achieved AUC up to 0.97 — meaning they correctly identify resistant vs susceptible bacteria in up to 97% of cases

AI Drug Discovery is Transformational

- Traditional drug discovery: 0.01–1% hit rate, costs billions, takes 10–15 years
- AI drug discovery: 59–100% hit rate — identifying working antibiotic molecules in months
- A deep learning model (Stokes et al.) screened 100 million molecules and found a brand-new antibiotic (Halicin) active against the most dangerous resistant bacteria

Discussion (2/2)

Implications for Indian Healthcare Settings

- Phase 1: Build local antibiogram database linked to EHR/LIS (Year 1)
- Phase 2: Deploy MALDI-TOF ML or EHR-based ML-CDSS for common infections (Year 1–2)
- Phase 3: Real-time AMR surveillance dashboard + ICMR-GLASS integration (Year 2–4)
- Phase 4: WGS partnerships with national reference laboratories (Year 4+)

Key Challenges Identified

- Regulatory gap: CDSCO lacks AIaMD evaluation framework
- Interpretability: Black-box models face structural adoption resistance from clinicians
- Infrastructure: WGS, bioinformatics expertise, EHR interoperability limited in polyclinics
- Privacy: DPDPA 2023 obligations must be embedded in AI system design from Phase 1

Conclusion

Summary of Findings

- 40 peer-reviewed studies (2017–2026) confirm AI is transformative across all AMR management domains
- Random Forest: most commonly used (47.5%) and consistently highest-performing algorithm (AUC up to 0.97)
- Deep RL-based antibiotic discovery achieves 100% in vitro hit rates — revolutionising the pipeline
- ML-CDSS (pooled AUC 0.89) — not LLMs — is the current evidence-based prescribing support standard

References

Key References (Vancouver Style)

- Ali T, et al. Artificial intelligence for AMR prediction. Antibiotics (Basel). 2023;12(3):523.
- Ardila CM, et al. WGS and ML for predicting AMR: systematic review. PeerJ. 2024;12:e18213.
- Bilal H, et al. Role of AI and ML in predicting and combating AMR. Comput Struct Biotechnol J. 2025;27:225–242.
- Cao H, et al. Deep RL platform for antibiotic discovery. bioRxiv. 2025.
- Cavallaro M, et al. Informing antimicrobial stewardship with explainable AI. PLOS Digit Health. 2023;2(1):e0000162.
- Harandi H, et al. AI-driven approaches in ASPs: systematic review. Artif Intell Med. 2025;162:103089.

INVOLVEMENT IN COMMUNITY OUTREACH PROGRAMME (COP) ACTIVITIES







KEY LEARNING FROM COP ACTIVITIES

- Developed an understanding of community health assessment and the role of primary healthcare services.
- Learned the importance of community mapping in identifying key resources and planning field activities.
- Gained experience in interacting with healthcare workers and community members during data collection.
- Enhanced communication, interviewing, and observational skills in a real-world setting.
- Understood the influence of social and environmental factors on health outcomes, particularly among diabetic patients.
- Acquired practical knowledge of field research methods, data collection techniques, and stakeholder engagement.

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PICTORIAL JOURNEY







Research Gap & Contributions

Research Gap This Study Addresses

- Existing studies focused on single pathogens, single algorithms, or single application domains
- No prior review synthesised all 5 AMR-AI domains simultaneously with equal methodological rigour.
- No comparative analysis of ML vs DL vs RL across AMR applications existed before this review

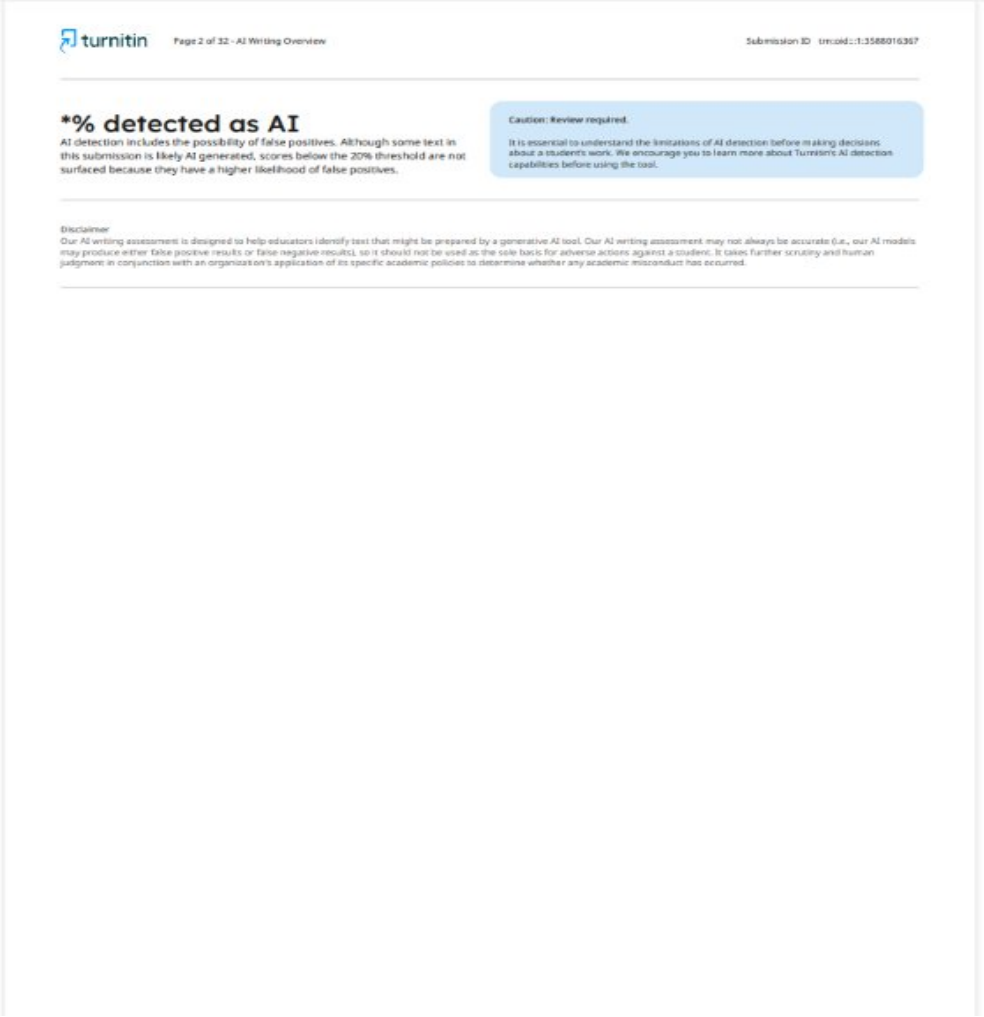
Original Contributions of This Dissertation

- PRISMA 2020-compliant synthesis of 40 real peer-reviewed studies (2017–2026)
- First systematic review covering all 5 domains: prediction, CDSS, drug discovery, surveillance, ASP
- Quantitative performance comparison: RF (AUC 0.89) > XGBoost (0.87) across 104,141 samples
- Evidence-based 4-phase implementation roadmap tailored to Indian polyclinic hospitals
- Identification of XAI as non-negotiable prerequisite for clinical AI adoption

Study Limitations

- English-language publications only — potential language bias
- Retrospective studies dominate — only 1 RCT (Stracy et al., 2022)
- Geographic bias: majority of studies from high-income countries

Plagiarism /AI approval



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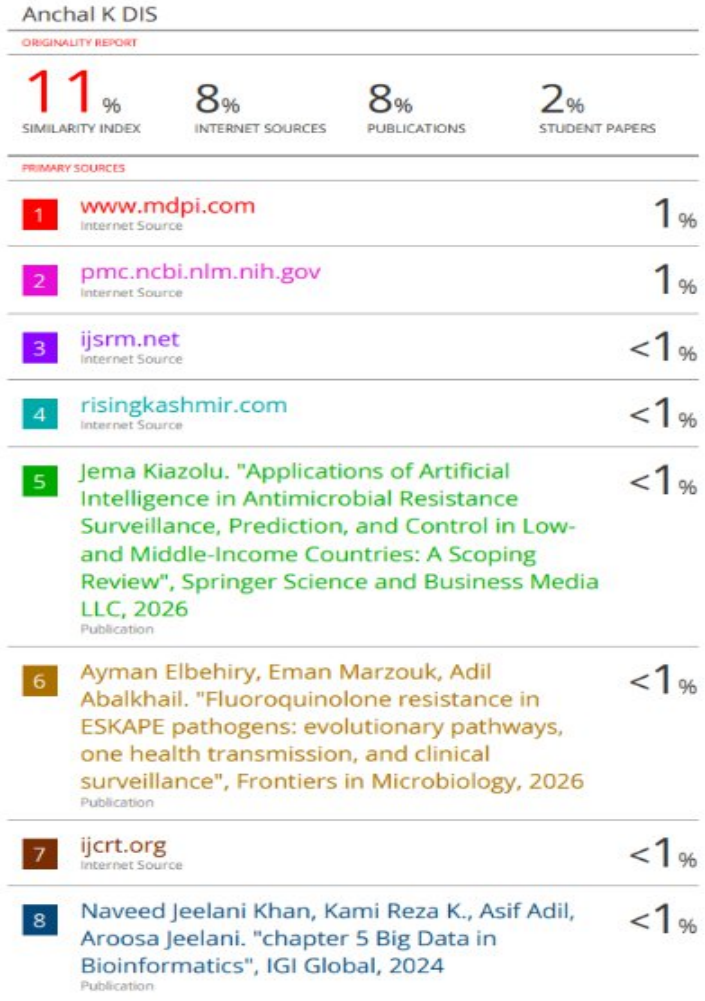
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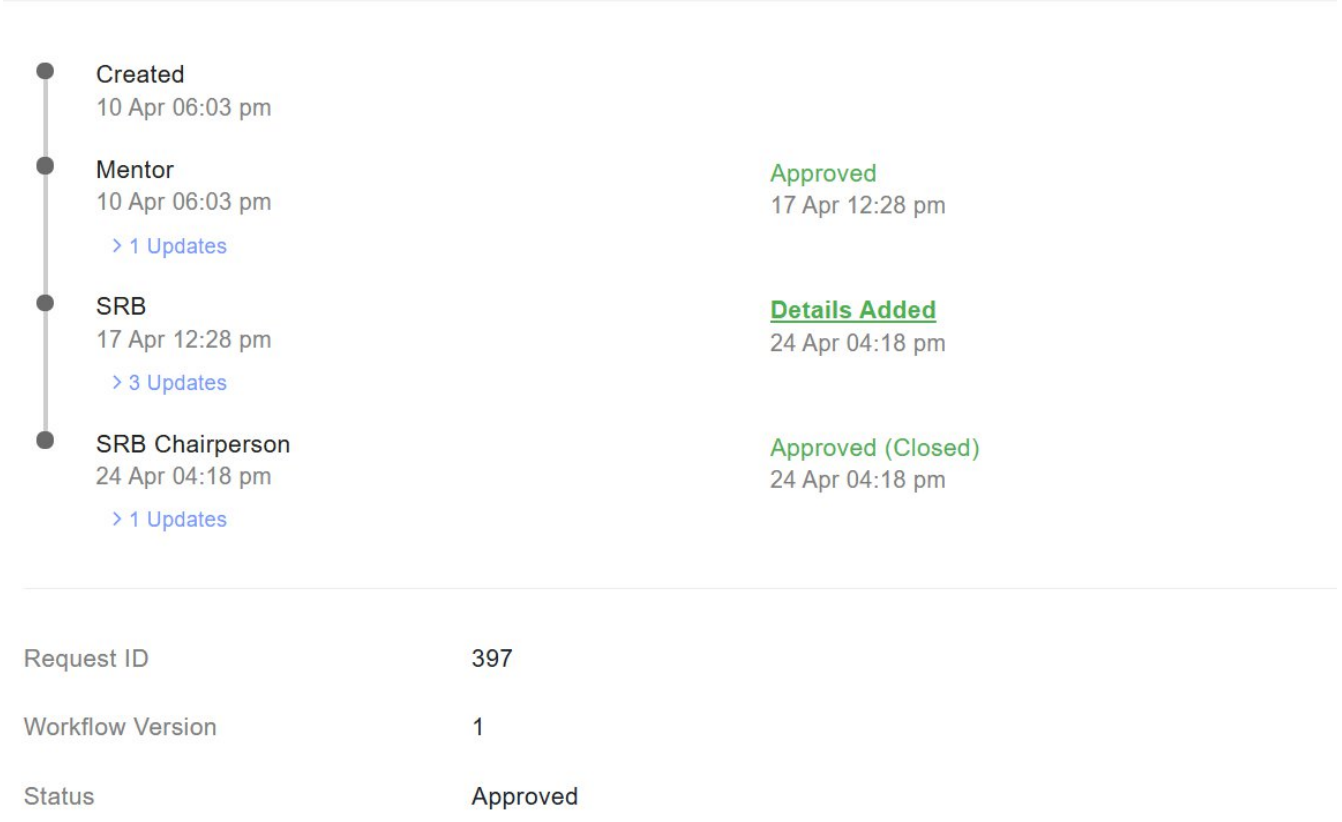
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