# Emergent applications of machine learning for diagnosing and managing appendicitis: a state-of-the-art review

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## INTRODUCTION:

- Atypical presentations and poor predictive value of laboratory tests complicate diagnoses of appendicitis
- Imaging improves sensitivity and specificity of diagnoses, but ultrasound has high operator dependency while CT scans involve radiation exposure.
- We conducted a state-of-the-art review to examine the use of emerging machine learning algorithms in improving appendicitis diagnosis and informing surgical interventions

## METHODS:

- Pertinent studies acquired from PubMed, Web of Science, and Embase retrieved over the date range of 2012 to 2022
- Studies had to include **at least one machine learning algorithm** and an analysis of **a dataset specific to appendicitis/appendectomy**
- Diagnostic algorithms must use pathology as gold standard

**QUERY:** ("machine learning" OR "artificial intelligence") AND ("appendicitis" OR "appendectom*")

***Full List of All 41 Included Studies:***

***Scan here***

## RESULTS:

After querying the aforementioned databases and filtering based on predefined criteria, **41 studies** were included. For a full list of reviewed studies, scan the QR code at the bottom left-hand corner of this poster or go to https://tinyurl.com/shaan-ML-appy-papers .

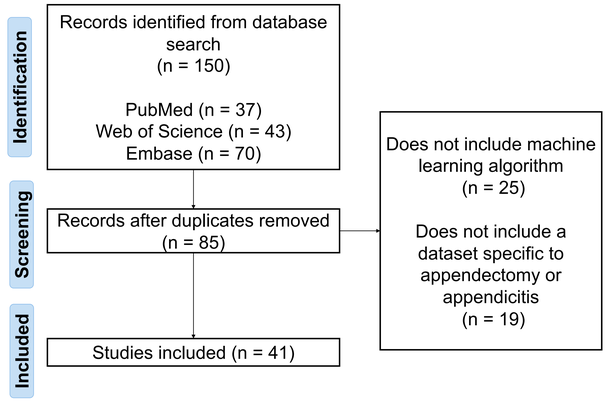



**FIG 2. PRISMA flow diagram for state-of-the art review.** After relevant screening based on inclusion criteria listed in Methods, 41 studies remained. Protocol was registered in Open Science Framework (osf.io/4u7gq).[1]

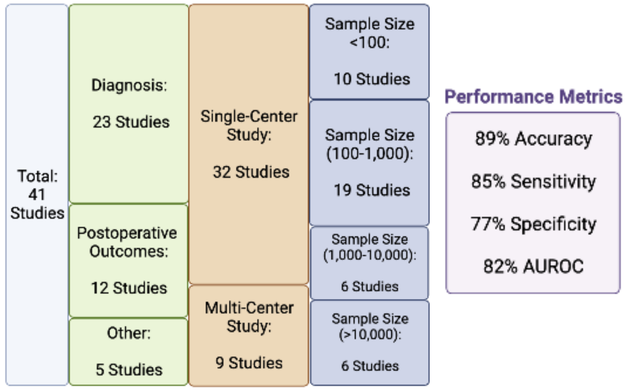



**FIG 3. Diagram of study characteristics and summary of average performance metrics.** AUROC was notably only reported in 14 studies. Diagrams created in BioRender.[2]

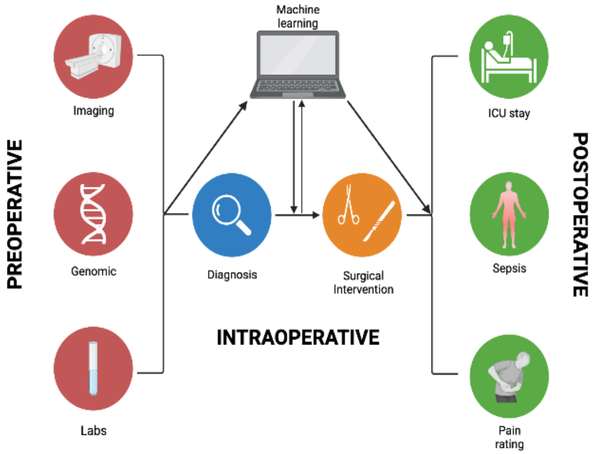



**FIG 4. Depiction of use cases for machine learning algorithms in retrieved literature**. Machine learning can use preoperative data to predict diagnosis and guide surgical decision-making, while also being capable of using preoperative and intraoperative data to predict postoperative outcomes. Diagram created in BioRender.[2]

| | Top Algorithms | Frequency (% Studies) | Algorithm Description |
|---|---|---|---|
| | Logistic Regression | 17% | Models outcome as a function of input variable; threshold value separates classifications |
| | Neural Network | 15% | Uses a layered structure of computational units, like neurons to map inputs to classification |
| | Random Forest | 12% | Groups of decision trees with test questions on subsets of the data, majority vote among the trees leads to classification |
| | Support Vector Machine | 7% | Maximizes margin/distance across a "hyperplane," a line separating classifications |

**FIG 5. Summary of optimal machine algorithms found in literature.** No algorithm seemed to be definitively superior. Diagrams of ML algorithms courtesy of Garrow et al., 2021 and Selmoune et al., 2022.[3]

## CONCLUSIONS & FUTURE DIRECTIONS:

- **No specific ML algorithm seemed to be unanimously superior across studies**
- Machine learning may **augment a clinician's ability to diagnose appendicitis** and help to **prepare for patient-specific post-operative complications** (use cases summarized in Fig 4.)
  - ❖ All 3 studies that compared performance to Alvarado scoring outcompeted the system in diagnostic accuracy
- More studies **comparing metrics like accuracy and AUROC for ML methods to that of standard diagnostic tools (Alvarado score, imaging, etc.)** are needed to assess advisability of implementation
  - ❖ Only 14 out of 41 studies reported AUROC

## REFERENCES:

1. Bhandarkar, S. R. (2023, January 18). Emergent applications of machine learning for diagnosing and managing appendicitis: a state-of-the-art review. OSF. Retrieved from osf.io/4u7gq
2. Adapted from "Risk Factors of Dementia", by BioRender.com (2022). Retrieved from https://app.biorender.com/biorender-templates
3. Garrow, C. R., Kowalewski, K.-F., Li, L., Wagner, M., Schmidt, M. W., Engelhardt, S., . . . Nickel, F. (2021). Machine Learning for Surgical Phase Recognition: A Systematic Review. Annals of Surgery, 273(4), 684-693. doi:10.1097/sla.0000000000004425
4. Selmoune, A., Liu, Z., & Lee, J. (2022). To pay or not to pay? Understanding public acceptance of congestion pricing: A case study of Nanjing. Electronic Research Archive, 30, 4136-4156. doi:10.3934/era.2022209