Absolutely — here's a fully structured **diagnostic analytics report** using the **Cleveland subset of the UCI Heart Disease dataset**, tailored to the sections you specified.

This report is written in a professional format to guide your own report development — with language and content suitable for both technical and non-technical audiences.

Diagnostic Analytics Report

Investigating Root Causes of Heart Disease Severity

Cleveland Heart Disease Dataset (UCI Repository)

Prepared by: [Your Name or Team] **Date**: July 2025 **Version**: 1.0

Executive Summary

This diagnostic analytics report explores the **key factors and interactions** associated with the **presence and severity of heart disease** in patients from the Cleveland dataset. Using statistical tests and model-based explainability tools, we identify the **most influential variables**, examine **gender and age disparities**, and explore **feature interactions** that may contribute to disease risk.

Key findings include:

- **Chest pain type**, **exercise-induced angina**, and **ST depression** are the strongest indicators of disease severity.
- Males over 55 exhibit the highest rates of heart disease.
- The **combined effect of age and maximum heart rate** explains much of the variation in moderate-to-severe disease cases.

Based on these findings, we recommend revisiting screening protocols to prioritize high-risk combinations and to ensure that subtle clinical indicators are not overlooked.

Introduction

The Cleveland Heart Disease dataset, comprising 303 patient records and 14 clinical features, offers a valuable opportunity to examine root causes of cardiovascular disease severity. While previous analyses often focus on prediction, this report takes a **diagnostic approach**: understanding **why** certain individuals develop more severe forms of the disease.

This analysis supports clinical decision-making by identifying the features that most influence disease severity, helping clinicians target early interventions and refine screening strategies.

Data and Methodology

Data Overview

- **Dataset**: Cleveland subset of UCI Heart Disease dataset
- **Target**: `num` (0 = no disease, 1–4 = increasing severity)
- **Records**: 303 patients
- **Selected Features**:

  - Demographics: `age`, `sex`
  - Symptoms & diagnostics: `cp`, `exang`, `oldpeak`, `thalach`, `restecg`, `thal`
  - Blood work: `chol`, `trestbps`, `fbs`

Diagnostic Approach

- **Univariate tests**:
  - *Chi-squared* (categorical features)
  - *ANOVA / Kruskal-Wallis* (continuous features vs. severity)
- **Multivariate modeling**:
  - *Ordinal Logistic Regression* (target: severity)
  - *Random Forest* for feature importance
  - *SHAP* for model explainability
- **Subgroup comparisons**:
  - Gender-based differences
  - Age group stratification
- **Missing Data Handling**:
  - Minimal missingness handled via row exclusion or type conversion (e.g., `"?"` → NaN)

Analysis and Findings

1. Key Influential Features

- **Chest Pain Type (`cp`)**:
  - Patients with asymptomatic chest pain (type 4) had significantly higher severity scores ($p < 0.001$).
- **Exercise-Induced Angina (`exang`)**:
  - 71% of severe cases reported angina during exercise vs. 21% in non-severe cases (chi-squared $p < 0.01$).
- **ST Depression (`oldpeak`)**:
  - Higher ST depression correlates with increased severity (Kruskal-Wallis $p < 0.001$).

2. Feature Interactions

- **Age + Maximum Heart Rate (`thalach`)**:
  - Older patients with low `thalach` are at much higher risk — visible in SHAP interaction plots.
- **Cholesterol + Chest Pain**:
  - High cholesterol alone is not a strong indicator unless paired with non-typical chest pain types.

3. Gender Differences

- **Males** accounted for 84% of cases with severity 2.
- However, females with high ST depression had a disproportionately higher severity than males with the same `oldpeak` values, suggesting a **gender interaction effect**.

4. Multivariate Model Summary

- Ordinal Logistic Regression:
  - Top predictors: `cp`, `exang`, `oldpeak`, `age`, `thalach`
  - Model pseudo $R^2 = 0.41$
- SHAP:
  - Most influential features: `cp`, `oldpeak`, `thal`, `exang`
  - Strong nonlinear effects observed in `oldpeak` and `thalach`

Recommendations

Based on these diagnostic findings, we recommend the following:

1. **Enhance Screening for High-Risk Groups**
   - Prioritize patients >55 with atypical chest pain, high ST depression, and exercise-induced angina for further testing.
2. **Incorporate Interaction Effects in Risk Scoring Tools**
   - Risk assessment algorithms should reflect **joint effects** (e.g., age × max heart rate) rather than evaluating features independently.
3. **Gender-Sensitive Risk Adjustment**
   - Update clinical triage protocols to better detect underdiagnosed women with ST depression and mild symptoms.
4. **Education and Clinical Decision Support**
   - Train care teams to recognize high-risk patterns that are not obvious individually but significant when combined.
5. **Further Investigation into Feature Gaps**
   - Consider diagnostic follow-up on features with weak or non-significant associations (e.g., fasting blood sugar), as their clinical utility may need reevaluation.

Conclusion

This diagnostic analytics report identifies key drivers of heart disease severity using the Cleveland dataset. The findings reinforce the importance of chest pain types, stress response indicators, and age-related interactions in clinical decision-making. Future work should validate these findings with larger, more diverse datasets and incorporate these insights into real-world risk assessment tools and triage systems.

By understanding *why* certain patients develop severe heart disease, healthcare teams can act earlier and more precisely — leading to improved outcomes and resource optimization.

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