



Improving Radiology Report Conciseness and Structure via Locally Run Large Language Models

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Introduction

Radiology reports often suffer from verbosity and lack of standardized structure, hindering efficient interpretation. This study explores locally run, open-source large language models (LLMs) to improve report conciseness and structure while ensuring data privacy and compliance with regulatory frameworks.

Hypothesis

Open-source LLMs, when deployed locally, can streamline radiology reports by reducing redundancy and organizing findings into a structured format, enhancing their readability and clinical utility.

Methods

We analyzed 814 de-identified radiology reports from seven board-certified body radiologists at Moffitt Cancer Center. Locally implemented LLMs, including Mixtral, Mistral, and Llama, were evaluated using the Ollama framework. Five prompting strategies were tested to restructure and condense reports, and the Signal-to-Noise Ratio (SnR) metric was developed to quantify meaningful content relative to redundant information. Key metrics included formatting accuracy, adherence to structure, and improvement in SnR.

Results

The "Structure + Conciseness (Findings, Impressions)" and "Conciseness >> Structure" prompting approaches performed best, achieving the highest SnR values and significantly reducing redundancy while maintaining or enhancing clarity. These methods also demonstrated fewer formatting errors compared to other strategies. Mixtral outperformed Mistral and Llama in adhering to structural instructions and producing concise outputs.

Conclusion

Locally run, open-source LLMs like Mixtral can securely and effectively enhance the clarity, conciseness, and structure of radiology reports. These findings demonstrate the potential for LLMs to improve radiology workflows while addressing critical data privacy concerns.

Figure(s)

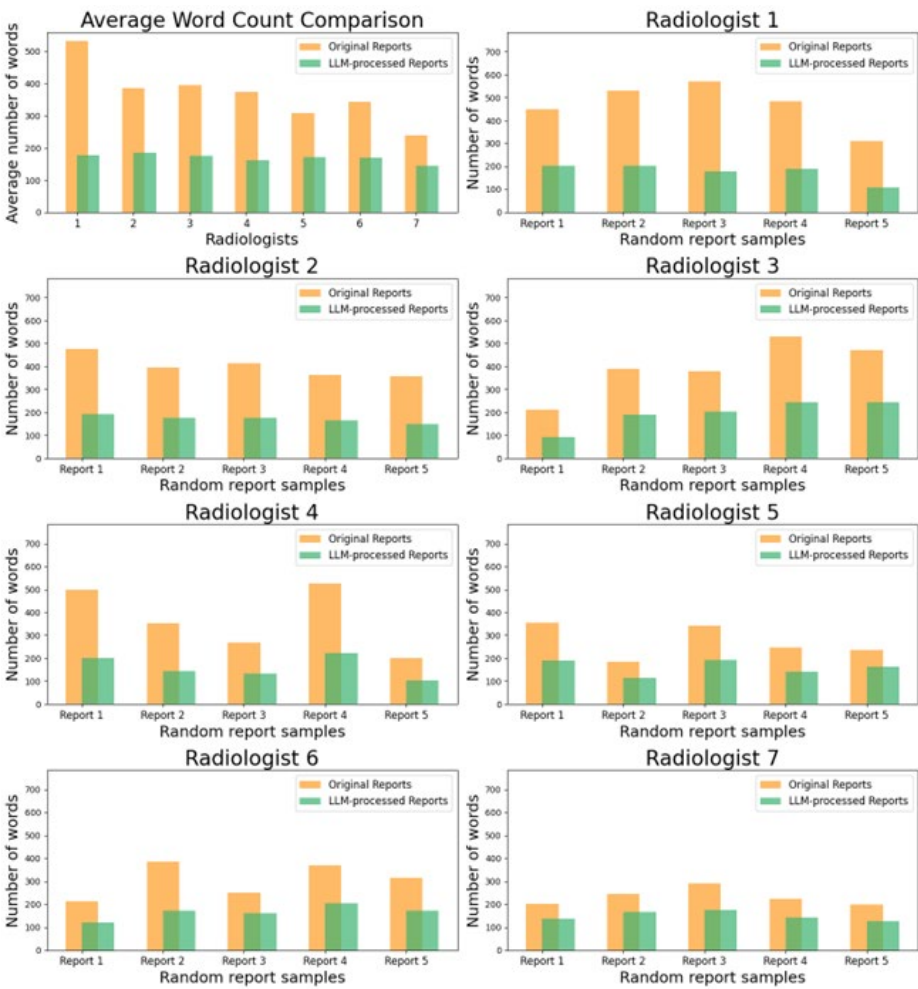


Figure 1. The upper left plot shows the average word count of the original reports and their successfully condensed versions generated by the Mixtral LLM (i.e., reports with CP scores not exceeding 100%). The remaining plots provide a side-by-side comparison of total word counts for a sample of original and LLM-processed reports. Five radiology reports were randomly selected for each radiologist, with CP scores between the 25th and 75th percentiles, indicating a mid-range level of conciseness. All reports were processed using the "Conciseness >> Structure" approach. This analysis highlights the effectiveness of the Mixtral LLM in streamlining content by reducing unnecessary words and phrases.

A Original Report (388 words)	B LLM-processed report, Structure (242 words) CP = 62.4%	C LLM-processed report, Structure + Conciseness (219 words) CP = 56.4%
<p>FINDINGS:</p> <p><i>Lines/tubes/devices:</i> Central line present with its tip in the right atrium</p> <p>CHEST:</p> <p><i>Lower neck/Thyroid:</i> Large heterogeneously enhancing mass in the left lobe of the thyroid. This is unchanged since the previous examination. The mass causes slight compression of the trachea at the thoracic inlet and deviated slightly to the right.</p> <p>Again noted on this examination are slightly prominent mediastinal lymph nodes. These are slightly smaller than on the previous examination and likely are related to the cardiomegaly and chronic congestive heart failure rather than metastatic disease.</p> <p>The heart is enlarged with scattered coronary artery calcifications. A central line is present with its tip in the right atrium.</p> <p>A small pericardial effusion is present and is smaller than it was on previous study.</p> <p>No pleural effusions are seen.</p> <p>On lung windows, no parenchymal masses or acute infiltrates are seen. The groundglass density, probably due to pulmonary edema, seen on the previous examination has resolved.</p> <p>Scanning through the abdomen demonstrates no free fluid. No masses are seen in the liver. No adrenal masses are seen.</p> <p>The pancreas and spleen are normal.</p> <p>No renal masses are seen. The right kidney is slightly atrophic compared to the left. No hydronephrosis is seen.</p> <p>No periaortic or mesenteric adenopathy is seen. Again noted on this examination is mild soft tissue thickening around loops of distal small bowel in the right lower abdomen. This is stable since prior studies and likely not clinically significant.</p> <p>Scanning through the pelvis demonstrates the uterus to be absent. The ovaries are visualized.</p> <p>Perirectal fat stranding is again noted and unchanged since previous study. The rectal wall thickening is less than it was on previous examination. There is no evidence of bowel obstruction.</p> <p>A small perirectal lymph node remains 0.3 cm in diameter which is unchanged since previous examination.</p> <p>The bladder is nondistended. No bladder masses are seen.</p> <p>On bone windows, the bones are generally osteopenic. There are moderate degenerative changes throughout the thoracic and lumbar spine.</p> <p>IMPRESSIONS:</p> <ol style="list-style-type: none"> 1. Improved congestive heart failure and pulmonary edema since prior study from 9/16/2023. The groundglass density in the lungs has resolved and the mediastinal lymph nodes have decreased in size. The pericardial effusion is also slightly smaller in the interval. The heart remains enlarged. 2. No evidence of tumor recurrence in the rectum. 3. Small perirectal lymph node remains stable. 4. No new abnormalities are seen. 	<p>FINDINGS:</p> <p><i>Lines/tubes/devices:</i> Central line present with its tip in the right atrium</p> <p>CHEST:</p> <p><i>Lower neck/Thyroid:</i> Large heterogeneously enhancing mass in the left lobe of the thyroid causing slight compression of the trachea</p> <p><i>Mediastinum:</i> Enlarged heart with scattered coronary artery calcifications and slightly prominent mediastinal lymph nodes</p> <p><i>Lungs/Pleural spaces:</i> No parenchymal masses or acute infiltrates, groundglass density probably due to pulmonary edema has resolved</p> <p><i>Other:</i> Small pericardial effusion</p> <p>ABDOMEN AND PELVIS:</p> <p><i>Hepatobiliary system:</i> None</p> <p><i>Spleen:</i> Unremarkable</p> <p><i>Pancreas:</i> Unremarkable</p> <p><i>Adrenals:</i> None</p> <p><i>Kidneys/Ureters:</i> Right kidney slightly atrophic compared to the left, no hydronephrosis</p> <p><i>GI tract:</i> Mild soft tissue thickening around loops of distal small bowel in the right lower abdomen, rectal wall thickening less than previous examination</p> <p><i>Peritoneum/Mesentery, Retroperitoneum, Vasculature, and nodes:</i> No free fluid, no periaortic or mesenteric adenopathy</p> <p><i>Reproductive organs:</i> Uterus absent, ovaries visualized</p> <p><i>Bladder:</i> Nondistended, no bladder masses</p> <p><i>Other:</i> Perirectal fat stranding, small perirectal lymph node</p> <p>BONES AND SOFT TISSUES: Osteopenic bones with moderate degenerative changes throughout the thoracic and lumbar spine</p> <p>IMPRESSIONS:</p> <ol style="list-style-type: none"> 1. Large left thyroid lobe mass with tracheal deviation 2. Enlarged heart with coronary artery calcifications 3. Resolution of groundglass opacity in lungs, likely due to resolved pulmonary edema 4. Small pericardial effusion 5. Mild small bowel wall thickening in right lower quadrant 6. Absent uterus and visualized ovaries 7. Perirectal fat stranding with a small perirectal lymph node 8. Osteopenic bones with moderate degenerative changes throughout the thoracic and lumbar spine 	<p>FINDINGS:</p> <p><i>Lines/tubes/devices:</i> Central line in right atrium</p> <p>CHEST:</p> <p><i>Lower neck/Thyroid:</i> Large heterogeneously enhancing mass in left lobe of thyroid with mild compression and deviation of trachea</p> <p><i>Mediastinum:</i> Enlarged heart with scattered coronary artery calcifications, slightly prominent mediastinal lymph nodes likely related to cardiomegaly and chronic congestive heart failure</p> <p><i>Lungs/Pleural spaces:</i> Improved congestive heart failure and pulmonary edema since prior study. No parenchymal masses or acute infiltrates.</p> <p><i>Other:</i> Unremarkable</p> <p>ABDOMEN AND PELVIS:</p> <p><i>Hepatobiliary system:</i> Unremarkable</p> <p><i>Spleen:</i> Unremarkable</p> <p><i>Pancreas:</i> Unremarkable</p> <p><i>Adrenals:</i> Unremarkable</p> <p><i>Kidneys/Ureters:</i> Right kidney slightly atrophic compared to left. No hydronephrosis.</p> <p><i>GI tract:</i> Mild soft tissue thickening around loops of distal small bowel in right lower abdomen, less rectal wall thickening than previous examination</p> <p><i>Peritoneum/Mesentery, Retroperitoneum, Vasculature, and nodes:</i> No free fluid, no masses, no periaortic or mesenteric lymphadenopathy</p> <p><i>Reproductive organs:</i> Absent uterus</p> <p><i>Bladder:</i> Unremarkable</p> <p><i>Other:</i> Unremarkable</p> <p>BONES AND SOFT TISSUES: Unremarkable</p> <p>IMPRESSIONS:</p> <ol style="list-style-type: none"> 1. Improvement in congestive heart failure and pulmonary edema compared to prior study 2. Large heterogeneously enhancing mass in left lobe of thyroid with mild compression and deviation of trachea 3. Enlarged heart with scattered coronary artery calcifications, likely related to chronic congestive heart failure 4. Slightly prominent mediastinal lymph nodes likely related to cardiomegaly and chronic congestive heart failure 5. Right kidney slightly atrophic compared to left, no hydronephrosis
D LLM-processed report, Structure >> Conciseness (222 words) CP = 57.2%	E LLM-processed report, Conciseness >> Structure (190 words) CP = 50.0%	F LLM-processed report, Structure + Conciseness (F, I) (193 words) CP = 49.7%
<p>FINDINGS:</p> <p><i>Lines/tubes/devices:</i> Central line present with its tip in the right atrium</p> <p>CHEST:</p> <p><i>Lower neck/Thyroid:</i> Large heterogeneously enhancing mass in left lobe causing tracheal compression and deviation to the right</p> <p><i>Mediastinum:</i> Slightly prominent mediastinal lymph nodes, enlarged heart with scattered coronary artery calcifications, small pericardial effusion</p> <p><i>Lungs/Pleural spaces:</i> Unremarkable</p> <p><i>Other:</i> Unremarkable</p> <p>ABDOMEN AND PELVIS:</p> <p><i>Hepatobiliary system:</i> Unremarkable</p> <p><i>Spleen:</i> Unremarkable</p> <p><i>Pancreas:</i> Unremarkable</p> <p><i>Adrenals:</i> Unremarkable</p> <p><i>Kidneys/Ureters:</i> Right kidney slightly atrophic compared to the left</p> <p><i>GI tract:</i> Mild soft tissue thickening around loops of distal small bowel in right lower abdomen, rectal wall thickening less than previous examination</p> <p><i>Peritoneum/Mesentery, Retroperitoneum, Vasculature, and nodes:</i> No free fluid. No periaortic or mesenteric adenopathy.</p> <p><i>Reproductive organs:</i> Uterus absent. Ovaries visualized.</p> <p><i>Bladder:</i> Nondistended. No bladder masses seen.</p> <p><i>Other:</i> Perirectal fat stranding and a small perirectal lymph node unchanged since previous examination</p> <p>BONES AND SOFT TISSUES: Generally osteopenic with degenerative changes. No acute bone lesions.</p> <p>IMPRESSIONS:</p> <ol style="list-style-type: none"> 1. Large heterogeneously enhancing mass in left lobe of thyroid causing tracheal compression and deviation to the right 2. Small pericardial effusion 3. Right kidney slightly atrophic compared to the left 4. Mild soft tissue thickening around loops of distal small bowel in right lower abdomen, rectal wall thickening less than previous examination 5. Perirectal fat stranding and a small perirectal lymph node unchanged since previous examination 	<p>FINDINGS:</p> <p><i>Lines/tubes/devices:</i> Central line tip in the right atrium</p> <p>CHEST:</p> <p><i>Lower neck/Thyroid:</i> Large heterogeneously enhancing mass in the left lobe of the thyroid, slight trachea compression and deviation to the right</p> <p><i>Mediastinum:</i> Enlarged heart with scattered coronary artery calcifications, small pericardial effusion</p> <p><i>Lungs/Pleural spaces:</i> Unremarkable</p> <p><i>Other:</i> Slightly prominent mediastinal lymph nodes likely related to heart failure</p> <p>ABDOMEN AND PELVIS:</p> <p><i>Hepatobiliary system:</i> None</p> <p><i>Spleen:</i> Unremarkable</p> <p><i>Pancreas:</i> Unremarkable</p> <p><i>Adrenals:</i> None</p> <p><i>Kidneys/Ureters:</i> Right kidney slightly atrophic compared to the left, no hydronephrosis</p> <p><i>GI tract:</i> Mild soft tissue thickening around distal small bowel loops in the right lower abdomen</p> <p><i>Peritoneum/Mesentery, Retroperitoneum, Vasculature, and nodes:</i> None</p> <p><i>Reproductive organs:</i> Absent uterus, visualized ovaries</p> <p><i>Bladder:</i> Nondistended bladder with no masses</p> <p><i>Other:</i> Perirectal fat stranding, a 0.3 cm stable perirectal lymph node, general osteopenia with moderate degenerative changes in the thoracic and lumbar spine</p> <p>BONES AND SOFT TISSUES: General osteopenia with moderate degenerative changes in the thoracic and lumbar spine</p> <p>IMPRESSIONS:</p> <ol style="list-style-type: none"> 1. Improved congestive heart failure and pulmonary edema since 9/16/2023 exam 2. No tumor recurrence in rectum 3. Stable small perirectal lymph node 4. No new abnormalities detected 	<p>FINDINGS:</p> <p><i>Lines/tubes/devices:</i> Central line in right atrium</p> <p>CHEST:</p> <p><i>Lower neck/Thyroid:</i> Large heterogeneously enhancing mass in left lobe, slight compression of trachea and deviation to the right</p> <p><i>Mediastinum:</i> Enlarged heart with scattered coronary artery calcifications, slightly prominent mediastinal lymph nodes likely related to cardiomegaly and chronic congestive heart failure</p> <p><i>Lungs/Pleural spaces:</i> Resolved groundglass density, no parenchymal masses or acute infiltrates</p> <p><i>Other:</i> Small pericardial effusion</p> <p>ABDOMEN AND PELVIS:</p> <p><i>Hepatobiliary system:</i> None</p> <p><i>Spleen:</i> Unremarkable</p> <p><i>Pancreas:</i> Unremarkable</p> <p><i>Adrenals:</i> None</p> <p><i>Kidneys/Ureters:</i> Right kidney slightly atrophic, no hydronephrosis</p> <p><i>GI tract:</i> Mild soft tissue thickening around loops of distal small bowel in right lower abdomen, less rectal wall thickening than previous examination, perirectal fat stranding and lymph node unchanged</p> <p><i>Peritoneum/Mesentery, Retroperitoneum, Vasculature, and nodes:</i> No free fluid or masses, no periaortic or mesenteric adenopathy</p> <p><i>Reproductive organs:</i> Absent uterus, visualized ovaries</p> <p><i>Bladder:</i> Nondistended, no bladder masses</p> <p><i>Other:</i> None</p> <p>BONES AND SOFT TISSUES: Generally osteopenic with moderate degenerative changes throughout the thoracolumbar spine</p> <p>IMPRESSIONS:</p> <ol style="list-style-type: none"> 1. Improved congestive heart failure and pulmonary edema since prior study from 9/16/2023 2. No evidence of tumor recurrence in the rectum 3. Small perirectal lymph node remains stable

Figure 2. The performance of the Mixtral LLM on making the unstructured radiology report concise and well-structured under various prompting strategies. (A) Unstructured radiology report alongside its corresponding LLM-processed versions using the following prompting approaches: (B) "Structure", (C) "Structure + Conciseness", (D) "Structure >> Conciseness", (E) "Conciseness >> Structure", and (F) "Structure + Conciseness (F, I)". The word count for each report is provided in parentheses. The CP scores of all LLM-processed reports are also indicated, with reports E and F having the lowest CP scores, making them the most concise.

Keywords

Artificial Intelligence/Machine Learning; Clinical Workflow & Productivity; Emerging Technologies; Security