APPENDIX

The models used for this study are as follows:

- **BASE**: This model does not use any information from clinical notes. So the tabular visit-level features d^i for every visit $i \in \mathcal{V}$ are directly passed through the FFN to make predictions.
- **NOTES**: This model follows the same architecture mentioned in the previous section but with LLM summaries replaced with the raw text of progress notes. This means that the text from the notes will be pre-processed and the embeddings will then be generated via the Clinical-Longformer model.
- **LLAMA3** [1]: This model uses our proposed framework with Meta's open-source LLM LLAMA3 8B [1]. LLAMA3 8B significantly outperforms its predecessor LLAMA2 7B not just in terms of the parameters but also across various benchmarks. Moreover, LLAMA3 8B has a knowledge cutoff of March 2023, which provides the model with knowledge of more recent topics and ideas.
- **MedLLAMA** [2]: This model uses a fine-tuned version of LLAMA3 8B as the LLM. The choice of using this model in this study was motivated by the fact that it is one of the top-performing models on The Open Medical LLM Leaderboard [3].
- **LLAMA3-Meerkat** [4]: This model also uses LLAMA3 8B as the base LLM model. The base LLM model is then fine-tuned with a synthetic dataset consisting of high-quality chain-of-thought reasoning paths sourced from 18 medical textbooks, along with diverse instruction-following datasets. Like the earlier baselines, this baseline uses LLAMA3-Meerkat as the LLM in our proposed framework.

Table I: ICU Stay Data for HADM ID 164300.

HADM ID	INTIME	OUTTIME	LOS
258902	2144-09-19 05:11:32	2144-09-19 18:31:29	0.5555
210169	2144-09-22 10:50:36	2144-09-24 12:07:56	2.0537
266607	2144-10-13 13:18:03	2144-10-21 16:00:55	8.1131
249692	2144-10-27 08:39:32	2144-10-31 18:12:40	4.3980

In addition to the overall analysis of the generated text, we also performed manual verification of the LLM text to demonstrate the benefit of the summaries generated by LLMs over using the raw text of clinical notes. We highlight the case of a patient with HADM ID (hospital admission ID) 164300 and SUBJECT ID 28941. This patient has had multiple visits to the ICU during current hospital admission. The duration of the visits is given in Table I. In this situation, we considered physician progress notes from visits spanning between 2144-09-22 10:50:36 to 2144-09-24 12:07:56 and 2144-10-13 13:18:03 to 2144-10-21 16:00:55. Figure 3 refers to the last physician progress note written during the visit for ICUSTAY ID 210169 while Figure 2 denotes the corresponding summary with future possible complications generated by LLAMA3.

Note that the LLAMA3 summary clearly outlines 'Respiratory Failure', 'Renal Failure', and 'Gastrointestinal (GI) complications' as potential medical complications, while the clinical note does not clearly outline any future complications that might arise. On the other hand, Figure 1 refers to the last physician progress note written during the visit for ICUSTAY ID 266607 during the same hospital visit of the patient with HADM ID 164300 (bounceback). We notice that the clinical note clearly states that the chief complaint was 'respiratory distress'. Furthermore, the patient also had 'severe acidosis' which is also caused by respiratory failure. Furthermore, the patient also had a 'positive urinalysis (UA)' could be caused due to renal failure. Thus, we can see that the LLM-generated summary clearly provides additional information about future outcomes, which in turn aids in improved patient risk estimation across multiple downstream tasks.

REFERENCES

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[4] H. Kim, H. Hwang, J. Lee, S. Park, D. Kim, T. Lee, C. Yoon, J. Sohn, D. Choi, and J. Kang, "Small language models learn enhanced reasoning skills from medical textbooks," *arXiv preprint arXiv:2404.00376*, 2024.

Chief Complaint: Respiratory Distress\n 24 Hour Events:\n PICC LINE - START [**2144-10-13**] 01:18 PM\n INVASIVE VENTILATION - START [**2144-10-13**] 01:30 PM\n ARTERIAL LINE - START [**2144-10-13**] 02:00 PM\n EKG - At [**2144-10-13**] 05:00 PM\n NPO for aspiration risk and possible extubation today\n **Abnormal EKG compared to prior**; starting cycling enzymes; negative x1\n so far\n History obtained from Patient, Family / [**Hospital 56**] Medical records\n Allergies:\n History obtained from Patient, Family / [**Hospital 56**] Medical [**Name2 (NI) 4484**] Known\n Drug Allergies\n Last dose of Antibiotics:\n Metronidazole - [**2144-10-14**] 12:52 AM\n Infusions:\n Fentanyl - 25 mcg/hour\n Midazolam (Versed) - 1 mg/hour\n Other ICU medications:\n Furosemide (Lasix) - [**2144-10-13**] 06:00 PM\n Heparin Sodium (Prophylaxis) - [**2144-10-14**] 12:53 AM\n Other medications:\n Changes to medical and family history:\n Review of systems is unchanged from admission except as noted below\n Review of systems:\n Flowsheet Data as of [**2144-10-14**] 06:28 AM\n Vital signs\n Hemodynamic monitoring\n Fluid balance\n24 hours\nSince 12 AM\n Tmax: 37.6\nC (99.7\n Tcurrent: 37.2\nC (99\n HR: 67 (65 - 91) bpm\n BP: 118/49(69) {99/44(59) - 172/85(117)} mmHg\n RR: 14 (14 - 24) insp/min\n SpO2: 100%\n Heart rhythm: SR (Sinus Rhythm)\nTotal In:\n243 mL\n160 mL\n PO:\nTF:\n IVF:\n153 mL\n131 mL\n Blood products:\n Total out:\n1,965 mL\n 205 mL\n Urine:\n1,965 mL\n205 mL\n NG:\n Stool:\n Drains:\n Balance:\n-1,723 mL\n-44 mL\n Respiratory support\n O2 Delivery Device: Endotracheal tube\n Ventilator mode: CMV/ASSIST/AutoFlow\n Vt (Set): 550 (550 - 550) mL\n RR (Set): 14\n RR (Spontaneous): 0\n PEEP: 5 cmH2O\n FiO2: 40%\n RSBI Deferred: Sao2 < 90%\n PIP: 25 cmH2O\n Plateau: 20 cmH2O\n SpO2: 100%\n ABG: 7.39/38/90.[**Numeric Identifier 128**]/22/-1\n Ve: 8 L/min\n PaO2 / FiO2: 225\n Physical Examination ..... Assessment and Plan\n THIS IS THE PLAN FROM YESTERDAY; PRELIMINARY NOTE FOR ROUNDS USE\n ONLY!!!!\n 59 y/o F with h/o mental retardation, recent dx of Nodular sclerosing\n Hodgkins Lymphoma s/p chemo on [**2144-10-9**] **presented with acute respiratory\n distress likely due to aspiration & mucus plugging** now intubated.\n .\n # Hypoxia: Likely due to aspiration & mucus plugging in the setting of\n depressed mental status, coughing and emesis. A component of volume\n overload cannot be excluded given her I/O positive >7 liters over the\n past several days. A primary lung reaction to her chemo is much less\n likely. Other possibilities including a primary cardiac event or PE are\n less likely with a relatively unchanged EKG and no tachycardia. Given\n rapid improvement of CXR after intubation, suspect that right lung\n white out was due to mucus plugging. ABG post intubation showed\n **signficant acidosis** with pH of 7.27.\n - increase RR & recheck ABG\n - advance ETT & recheck placement\n - no need for Abx currently\n - f/u sputum Cx & low threshold to start ABx if spikes temp\n - wean sedation, SBT & RSBI in am\n - continue regular suction & albuterol MDI\n - diuresis goal neg 1-2L\n - consider thoracentesis for diagnosis & therapeutic\n - recheck EKG (given pseudonormalization on tracing from am)\n - cycle CE to ROMI\n # Hodgkins Lymphoma: Pt is s/p EACoPP protocol on [**2144-7-21**] with\n cytoxan, doxorubacin on day 1 and etoposide on days [**2-13**]. Pt has also\n had pericardial tamponade s/p pericardiocentesis on [**2144-6-24**] and\n pericardial window on [**2143-7-25**]. Pt initiated ICE chemo reg on [**2144-10-9**].\n This acute hypoxia more likely due to aspiration & mucus plug, unlikely\n due to chemo toxicity.\n - continue Acyclovir & Bactrim ppx\n - f/u Onc recs\n - transfuse to maintain hct>25\n .\n # H/o megacolon/Diarrhea: Pt is s/p volvulous & sigmoid resection with\n large dilated loops of colon visible on portable films. She has\n required intermittent rectal tubes, currently having alot of stool\n output with recent C. Diff toxin + [**2144-8-8**] & [**2144-9-1**].\n - will keep NPO for now (possible extubation in am)\n - continue po vanco & IV flagyl\n - place rectal tube now\n - OG tube to intermittent suction\n - f/u C diff toxin\n - repeat imaging in am\n .\n # Paroxysmal A-fib: Recent adm to ICU due to poor rate control (rates\n of 160 with relative hypotension). Rates have been better controlled on current regimen of Metoprolol, Amiodarone & Diltiazem. No plan for\n anticoagulation due to bloody pericardial effusion. Currently in NSR\n with rate in 60s.\n - continue Metoprolol & diltiazem & amiodarone\n - f/u repeat EKG\n .\n # UA: **Pt had positive UA** on [**10-11**], Urine Cx + fungus 4000-6000 CFUs.\n Received fluconazole 400mg x 1\n - change out foley now\n - resend UA & Urine Cx\n - hold off on Fluconazole for now\n .\n # F/E/N: IVF prn, NPO for now, OG tube to intermittent suction\n - replete lytes agressively\n .\n # PPX: heparin SQ, PPI\n .\n # CODE: Intubate/DNR\n .\n # ACCESS: L PICC, working on PIV\n .\n # CONTACT: HCP - brother [**Name (NI) 3080**] [**Telephone/Fax (1) 3081**] (mobile) and [**Telephone/Fax (1) 3082**]\n (home); brother also gave permission to speak with his wife [**Name (NI) **]\n ICU Care\n Nutrition:\n Glycemic Control:\n Lines:\n PICC Line - [**2144-10-13**] 01:18 PM\n Arterial Line - [**2144-10-13**] 02:00 PM\n Prophylaxis:\n DVT:\n Stress ulcer:\n VAP:\n Comments:\n Communication: Comments:\n Code status: DNR (do not resuscitate)\n Disposition:\n

Figure 1: First Physician Progress Note for the ICU visit on 2144-10-14 06:28:00 for HADM ID 164300.

Based on the provided progress note, the patient is a 59-year-old female with mental retardation, recently diagnosed with Nodular Sclerosing Hodgkin's Lymphoma, and admitted to the ICU for atrial fibrillation with rapid ventricular response. The patient has a history of chemotherapy, and currently, she is receiving IV amiodarone, cefepime, and lasix.

The patient's vital signs are stable, with a temperature of 36.3°C, heart rate of 97 bpm, blood pressure of 102/48 mmHg, and respiratory rate of 28 inspirations per minute. Her oxygen saturation is 95% on nasal cannula.

The patient has several medical complications, including:

1. Neutropenia: The patient is neutropenic, and GCSF is being continued per BMT service. Monitoring of daily ANC counts and maintenance of neutropenic precautions are recommended.
2. LUL infiltrate: The patient has a possible left upper lobe infiltrate on CXR, and cefepime has been started due to neutropenia.
3. Hemopericardium: The patient has a moderate pericardial effusion without tamponade physiology, and further monitoring of vital signs is recommended.
4. Lymphoma: The patient has completed one cycle of chemotherapy and has a history of c. diff colitis and oral/genital herpes.
5. UTI: The patient has completed a course of linezolid and ceftriaxone for UTI and will be followed up with repeat UCx.
6. Anemia: The patient has chronic iron deficiency anemia and is now experiencing it due to chemotherapy.
7. R upper limb DVT: The patient has a history of superficial thrombus in the right upper limb and is not receiving anticoagulation due to hemopericardium.
8. Ileus/abdominal distention: The patient has not had a bowel movement since [**2144-9-21**] and is experiencing abdominal distention. Frequent patient repositioning, rectal tube, and simethicone as needed are recommended.
9. h/o C. diff: The patient has a history of c. diff and is currently receiving oral vancomycin.
10. HSV oral ulcer: The patient has an oral ulcer treated with ACV, and continuation of ACV prophylaxis dose is recommended.

Potential medical complications that can arise include:

1. Sepsis: Given the patient's neutropenia and possible LUL infiltrate, there is a risk of developing sepsis.
2. Tamponade: If the patient's pericardial effusion worsens, there is a risk of developing tamponade physiology.
3. Hemorrhage: The patient's history of hemopericardium and neutropenia increases the risk of bleeding.
4. **Respiratory failure: The patient's atrial fibrillation and possible LUL infiltrate increase the risk of respiratory failure.**
5. **Renal failure: The patient's history of chemotherapy and possible UTI increase the risk of renal failure.**
6. **GI complications: The patient's history of c. diff and possible ileus/abdominal distention increase the risk of GI complications.**

Overall, the patient requires close monitoring and management of her medical complications to prevent further deterioration of her condition.

Figure 2: LLAMA3 Summary for the Progress Note for the ICU visit on 2144-09-24 06:29:00 for HADM ID 164300.

Chief Complaint:
24 Hour Events:
Allergies:
Other ICU medications:
Heparin Sodium (Prophylaxis) - [**2144-9-23**] 08:56 AM
...
Assessment and Plan
59F with mental retardation w/ recent dx of Nodular sclerosing Hodgkins Lymphoma s/p chemo; readmitted to ICU for Afib with RVR..
Atrial fibrillation: Unclear precipitant. (? pneumonia). Pt has converted to sinus last PM with Amio gtt.
- appreciate cardiology input
- IV amiodarone gtt will d/c a t 18:30
- call cards for PO amio dose
- IVF boluses prn
- Lasix and Metoprolol home doses started this AM
- EKG today
- no heparin gtt given h/o hemopericardium.
Neutropenia:
- continue GCSF per BMT service
- monitor daily ANCs
- maintain neutropenic precautions
- Started cefepime
- f/u BCx.
LUL infiltrate: per read on [**9-19**] CXR. Patient started on cefepime as pt neutropenic # Hemopericardium: Moderate pericardial effusion per ECHO on [**2144-9-15**] without evidence of tamponade. [**9-21**] ECHO showed smaller effusion without tamponade physiology.- continue to monitor VS- should VS become deranged, would check pulsus and consider repeat echo
Lymphoma: NSHL as per pathology from supraclavicular LN biopsy.
Completed one cycle of chemo, c/b c. diff colitis and oral/genital herpes. BMT service to follow while in ICU
UTI: s/p linezolid and ceftriaxone complete course - f/u repeat UCx
Anemia: Chronic, iron deficiency anemia and now s/p chemo. - maintain Hct >25, plt >75 given hemopericardium
R upper limb DVT: US on [**8-31**] showed superficial thrombus. - no anticoagulation for now given h/o hemopericardium
Ileus/abdominal distention: Last BM on [**2144-9-21**] frequent patient repositioning. rectal tube if significant symptoms. simethicone prn
h/o C. diff: s/p IV flagyl that was completed on [**2144-8-30**] continue po vancomycin
HSV oral ulcer: Treated with ACV contine ACV ppx dose
F/E/N: IVFs prn / replete lytes prn / regular, neutropenic diet with soft, thin liquids
...

Figure 3: Last Physician Progress Note for the ICU visit on 2144-09-24 06:29:00 for HADM ID 164300.