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Title	Effect of COVID-19 on computed tomography usage and critical test results in the emergency department: an observational study in Ontario, Canada
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Reviewer 1	Edmund Kwok
Institution	University of Ottawa, Emergency Medicine
General comments (author response in bold)	Comments to the Author Major comments: The authors sought to determine the impact of the COVID-19 pandemic on diagnosis of "new or acute" illnesses in the ER using CT imaging. While the subject is topical and it would interesting to understand more how the pandemic has impacted specific imaging utilization, the study design and data presented are suboptimal in answering the objective posed by the investigators. Below are some of the issues worth addressing to help improve the quality of the manuscript: **R1.1.** -Why was the month of April used as the study period? It doesn't not seem to align with actual official dates related to the COVID-19 pandemic. This is critical if the study is to truly assess the direct impact of the pandemic. The initial outbreak of the novel coronavirus began in Jan 2020; WHO officially declared global pandemic March 11th 2020; and Ontario official social distancing policies were announced March 16th 2020. The greatest impact on overall ED volumes happened during the last half of March 2020. It would be helpful for readers to understand the rationale for only examining Apr 2020 vs 2019, knowing the major milestone dates of the pandemic itself. **Response: There are several key dates on which announcements were made to the Ontario public including up to the end of March. For example, non-essential businesses were ordered to close for 14 days on March 23rd, an emergency alert was sent to recent travellers on March 27th, and all outdoor amenities were shut down on March 30th. We believed that April 1–30 would most adequately capture the change in volume post-pandemic. We compared to April from one-year prior rather than a few months prior to avoid bias introduced from season-to-season variations in ED imaging patterns.** **R1.2.** -Please provide actual ED visit/volume data. Without knowing the impact of the pandemic on overall ED visits, it is very difficult to interpret CT imaging rates for this population (i.e. only having the numerator without the denominator). It would be very helpful to see if ED physician ordering behaviour was affected during the pandemic. As it stands, it is unclear whether the decrease in CT examinations in this study was a result of a proportional decreased in overall ED volume; decrease only in patients with acute clinical findings of concern; or change in ED physician ordering behaviour, etc.. **Response: The main focus of our study was not to determine the rates of CT in the ED during the pandemic. It was to establish the impact of the pandemic on the *diagnosis* of new or acute illness in the ED compared to a similar pre-pandemic period. Ideally the number of cases diagnosed could be compared to the true total number of cases as a reference standard, however it is not feasible and perhaps not possible to establish the number**

	of new or acute illnesses that never presented to the ED or that were misdiagnosed in the ED during the pandemic. We state in our *Interpretation* section on page 6 that our findings imply these diseases were either *less common* or were *less commonly diagnosed*. This is true regardless of whether or not the cases presented to the ED. **Incorporating ED visit numbers and other patient data was beyond our scope. We have added the following to our limitations paragraph on page 7:** **"Another limitation is that we did not analyze the pattern of CT examinations pre- and post-pandemic in relation to the pattern of ED visits and other patient data."** **R1.3.** -There is some ambiguity around definitions of "new/urgent" findings. The authors state that they assigned CT examinations as whether "new or acute pathology that may require urgent management", although it is unclear how they actually arrived at those definitions, especially the "urgent management" part. They also had to exclude all non-CTPA chest examinations to avoid "confounding effects", which potentially would have missed some cases even though the ED doc may not have been concerned about COVID pneumonia. Finally, they also defined certain findings as "incidental and of doubtful clinical significance", which once again one could argue is quite subjective. For example, a ureteric calculi on CT quite often is a minor ED diagnosis that is treated as a outpatient with pain control (listed as new/acute urgent diagnosis in this study); while a patient with fat-containing hernia with intractable pain may need inpatient admission (categorized as "doubtful significance in this study). All these issues could be better addressed if the authors provided actual final diagnoses and objective outcome data (e.g. admission, direct to OR, etc), which would really add to the robustness and strength of the findings. **Response: Until now, it had been unclear if the reduction in new or acute pathologies diagnosed in the ED during the COVID-19 pandemic had been due to fewer patients with new/acute illnesses, fewer patients without new/acute illnesses, or both. We sought to address this by executing a comprehensive analysis studying both specific disease types and also by dividing patients into two groups; those with and without new or acute findings. We reviewed every CT report systematically, consistently and in detail to establish if there were new or acute findings relevant to patient care. We believe our categorization was robust and reproducible. We have added the following point to clarify the definition of new or acute pathology that we used on page 3:** **"This included any pathology that was previously unknown and required new specific management (e.g. new malignancy), any new pathology explaining an acute presentation (e.g. ovarian torsion), and any pre-existing pathology with an acute complication (e.g. Crohn disease with active inflammation) or interval worsening (e.g. worsening metastatic disease)."** **While it is true that a ureteric calculus does not always result in severe abdominal pain, we disagree that a ureteric calculus on CT is often a minor diagnosis when performed for a patient presenting to the ED with flank pain; these can be very debilitating for patients. Similarly, while some fat**

	containing hernias can result in severe pain, the vast majority are incidentally detected on CT and unrelated to the patient presentation. If a fat-containing hernia showed signs of strangulation or acute inflammation on CT, or if it corresponded to the symptomatic site and there was no other explanation for pain, it would have been documented as an acute finding in our study. **It is correct that excluding chest CT exams could have removed some acute cases from our cohort; however, the number of chest CT exams removed was very small relative to the size of our overall cohort at 50 CTs. We believe it was more advantageous than detrimental to remove them given the potential for bias introduced by chest CT exams performed to assess COVID-19. We have added this information to the manuscript to clarify on page 3.** **We agree that analysis of a variety of morbidity and mortality metrics would be informative, however our focus was specific to disease diagnosis in the ED. It was beyond the scope of our study to explore patient outcomes. It is also perhaps premature to determine these outcomes given the relatively recent onset of the pandemic.** **R1.4.** -Is it actually useful to examine each CT modality by # of scans/day? The numbers are quite small for most of them (e.g. in Table 2, CT head/neck only had 1/day), and I am not convinced the statistical analysis done on these small numbers are robust to identify true differences. Given the short 1-month period of the study, it would be better to compare using traditional pre-/post- of the entire study period, instead of # of scans/day. This applies to Table 3 as well; it is really is not informative to try and compare such low # of scans/day. **Response: CT exam numbers were compared on a daily basis rather than comparing the absolute totals so that differences between central tendencies could be calculated pre- and post-pandemic. It is true that a larger cohort would have increased statistical power for several outcomes and may have resulted in identification of more significant differences; however, we still found multiple significant difference that are very revealing and informative.** **R1.5** -The data presented does not seem to support the authors' conclusion. They claim that "new and acute pathologies" of the head and chest were less common/commonly diagnosed during the pandemic; however Table 4 clearly shows otherwise. There was no significant difference between pre-/post- periods. The authors appeared to draw that conclusion from the faulty Table 3 (as discussed earlier), where they compared tiny numbers of scans/day and tried to do statistical analysis on such tiny numbers. Ultimately I am not convinced with their own data to support that "there were significantly fewer new/acute pathologies diagnosed on head CT and CTPA during the pandemic". **Response: We should emphasize that the lists of specific pathologies for each body region are not collectively exhaustive. For example, a new brain tumor diagnosed on CT would not have been captured on our list of pre-defined specific pathologies for the head (as in Table 4) however would have**

	been documented as a CT showing a new or acute finding. We have added the following to the manuscript on page 3 to clarify: **"This list was not collectively exhaustive for each body region but rather was used to assess several more common and urgent pathologies."** Minor comments: **R1.6** -The term Emergency Departments (ED) are preferable to Emergency Rooms (ER). **Response: Agree. We have updated the title, manuscript, tables and figures to read Emergency Department (ED) rather than Emergency Room (ER).** **R1.7** -Were all ED sites similar in terms of impact of COVID? This is important since you took aggregate CT data and pooled them together. If certain centers were more impacted (e.g. some centers ended being more of the go-to low acuity COVID screening site, while academic centres being the critically ill COVID ICU site, etc), might need to consider separate analyses. **Response: The impact on ED CT imaging at all four sites was not significantly different. We performed a Kruskal-Wallis test comparing the drop in CT volumes for each separate ED and found there was no difference (page 5). We did not study ED visits.** **R1.8.** -Figures 1-3 are not necessary. They do not really add much value, and are not visually intuitive, with a lot of messy data points. **Response: We have modified Figures 1 and 3 by removing the individual datapoints to reduce visual clutter. We believe Figures 1–3 are visually informative and will help readers understand the trends in CT exams. We have used the "Viridis" colour palette in R which was designed to be perceptually uniform, robust to colorblindness and also converts well to greyscale.** **R1.9.** -Table 4 may benefit from not only showing absolute numbers, but rate of positive findings (i.e. divided by total scans done) **Response: We respectfully disagree. Dividing the numbers of cases currently listed in Table 4 by the overall total number of CT exams would not provide any additional meaningful information. The ideal fraction to present would be the number of cases diagnosed (which are currently presented) divided by the true total number of cases in the population. Unfortunately, it is not possible to establish the true number of cases since the number of undiagnosed cases is not obtainable.**
Reviewer 2	Lee Treanor
Institution	University of Ottawa, Department of Medicine
General comments (author response in bold)	Comments to the Author Here are some points where I feel the authors could present their data better and explain certain topics more.

	R2.1. Is there any available quantitative data which could inform the readers on the change in total number of ER visits by patients? **Response: Yes. We have added the following line to our *Results* section on page 5 regarding total number of ED visits prior to and during the pandemic:** **"During the same period, the total number of ED visits decreased by 52%."** **R2.2.** Considering the authors have results showing the increase in CT examination from years prior to 2020 steadily increasing (and mentioned supporting references for this claim), and have shown a decrease in "non-positive" testing, I think the author's should comment further on if this points to over-testing, or if they have another explanation? Would be an interesting point to expand on. **Response: We agree that the relatively larger decrease in CT exams without new or acute findings during the COVID-19 pandemic is interesting. It is difficult for us to comment on the reasons behind the disproportionate growth in imaging relative to ED visits leading up to the pandemic as we did not collect or analyze this data as it was beyond our scope. We have added the following to our *Interpretation* section on page 7:** **"It is possible that this increase had been due in part to over-testing prior to the pandemic."** Some particular points: Methods: **R2.3.** I think the authors should further expand on the criteria they used to determine acuity, more than simply, "a priori for each body region." **Response: We have added the following additional detail to clarify our criteria on page 3 of the *Methods* section:** **"This included any pathology that was previously unknown and required new specific management (e.g. new malignancy), any new pathology explaining an acute presentation (e.g. ovarian torsion), and any pre-existing pathology with an acute complication (e.g. Crohn disease with active inflammation) or interval worsening (e.g. worsening metastatic disease)."** Results: **R2.4.** Add more descriptive statistics into the results. How come in the abstract the authors specify the number of CT examinations per day, but you do not in the results (only in the figures)? **Response: We have added the number of CT exams per day to the *Results* section on page 5. Please note we have tried to meet the journal's criteria of not duplicating data in tables, figures and text.** Interpretation:

	R2.5. Page 6, line 15: Specify the geographic location where the data from the ER visits during the Hantavirus epidemic was gathered. **Response: We have added the following on page 6:** **"…including the 1993 Hantavirus epidemic (in New Mexico, Arizona and Colorado)…"**
Reviewer 3	Lynne Moore
Institution	Université laval, Social and, Social and preventive medecine
General comments (author response in bold)	Comments to the Author This retrospective cohort study aims to determine the impact of the pandemic on the diagnosis of new or acute illness in the ER. To do so, authors compare mean daily number of CT scans in the ER before and during the pandemic and their yield in terms of new/acute pathologies. They observe fewer CTs and fewer new/acute pathologies during the pandemic but CTs had a higher yield. Their take home message is that public health should work to raise awareness on the importance of consulting at the ED for acute illness not related to COVID-19. I realise that the goal is very quick turn around on pandemic research but I have several concerns with this paper in terms on methods and interpretation of results. I'm also uncertain that results advance knowledge on the subject. **R3.1.** I think there should be more discussion on low-value imaging. Pandemic CT scans did not yield results suggesting that delayed presentation was detrimental. This may suggest that overuse of imaging techniques pre-pandemic was the problem. Furthermore, to me the increase in CT imaging up to 2019 is just as noteworthy as the decrease during the pandemic. In fact, if I'm not mistaken, according to Figure 2, rates of CT during the pandemic were higher than rates in 2015. What could explain this? Is it another indication of overuse of imaging? Authors suggest that decrease in imaging was uniquely due to patients presenting less frequently. Could it also be due to physicians using less scans (including fewer repeated scans) in patients presenting to the ED? Authors should also discuss the decrease in scans due to the natural decrease in pathologies due to lockdown, particularly trauma. **Response: It is difficult for us to comment on the reasons behind the disproportionate growth in imaging relative to ED visits leading up to the pandemic as we did not collect or analyze this data as it was beyond our scope. We agree that our findings may raise concerns regarding over-testing leading up to the pandemic. We have added the following to our *Interpretation* section on page 7:** **"It is possible that this increase had been due in part to over-testing prior to the pandemic."** **We have added the following to our limitations paragraph to address the possibility of variables that could not be accounted for impacting overall scan numbers:** **"There are many variables that could potentially lead to a reduction in ED visits during the pandemic including reduced motor vehicle transportation during the lockdown, lack of elective surgeries with subsequent post-**

	operative complications, and others that could not be controlled for in our analysis." **R3.2.** The Background section of the abstract is expressed as an objective. **Response: Agree. We have restructured the *Background* section to not read as an objective, on page 1:** **"The impact of the COVID-19 pandemic on the diagnosis of new or acute illnesses in the emergency department (ED) is unclear."** **R3.3.** The introduction is well-written but the justification for this study over and above literature already demonstrating decrease in healthcare use for acute illness (ref 10-15) could be made clearer. Why use CTs to answer this question rather than diagnostic information in ED databases? **Response: We have added the following line to the *Introduction* section on page 2 and have also added emphasis that we are interested in the impact of COVID-19 on disease *diagnosis*:** **"There are however little to no data comparing the impact of COVID-19 on the diagnosis of pathologies of different urgency. Furthermore, many acute pathologies have not been independently assessed."** **The focus of our study was disease diagnosis and CT is a broadly used tool for establishing the diagnosis of a large variety of pathologies affecting multiple body regions. Reviewing ED records for descriptions of diagnostic test findings would not have provided the same level of detail directly available in CT reports. Furthermore, ED records describing diagnostic test results can be inconsistent and incomplete.** **R3.4.** A clearer alignment between objectives, methods, results and conclusions would be helpful. I suggest giving specific objectives in addition to an overall objective (e.g. impact on number of new/acute diagnoses, impact on delay in presentation, long-term trends, and variations between hospitals). The hypotheses underlying the first two study objectives are clear but not the third and fourth (e.g. regional variations in SES could affect consulting behavior). **Response: In response to feedback from the editors (comment E4 above), we have restructured the presentation of the *Methods* and *Results* sections by dividing each into data derived from multiple sites and single site data. We agree this clarifies the study structure. While the first two points listed here are indeed objectives, we did not consider long term trends an objective; we presented the CT volumes from 2015 to 2020 in Figure 2 simply to visually demonstrate that the reduction in cases during the pandemic was clearly an aberration from normal year-to-year variation. The reason we included data from multiple sites was to confirm that the reduction in CT volumes during the pandemic was a widespread phenomenon in Ontario.** **R3.5.** Among gaps in knowledge this study aims to fill is the following question

	(Introduction): Are acute illnesses being misdiagnosed? I don't understand the underlying hypothesis and I don't think your study answers this question. **Response: Agree. This was intended as background commentary but perhaps is misplaced. We have removed this statement from the *Introduction* section on page 2 to avoid confusion.** **R3.6.** Methods: Aggregated data on numbers of CT were pooled across sites. Individual-level data was available for one center. Of the four objectives I stated above, the first and third were examined using aggregate data. Since there was no information on diagnoses for aggregate data, these objectives could therefore not be specific to new/acute diagnosis. This should be stated in the limitations. Statistical methods are suboptimal. Numbers of CT is a count variable (unlikely to be Gaussian!) and could be modelled with Poisson regression. Also, time series could be used. I know obtaining timely results is an issue but an analyst familiar with R (software used for analysis) is probably capable of more sophisticated analyses. Multiple comparisons should be accounted for. **Response: Regarding the lack of individual data from all sites, we have updated our limitations paragraph as follows on page 7:** **"Limitations of this study include the relatively short period of data collection and the lack of *individual-level data* from all four sites."** **We have updated our statistical methods as recommended by the editors (comment E3 above). It is correct that count data are often skewed, which was the case for most of the parameters we collected and is why we calculated comparisons using non-parametric techniques. While we explored multiple outcomes, we only considered one explanatory variable for each, which was pandemic vs pre-pandemic.** **R3.7.** Results: Tables 1 and 2– would be important to give total n for each hospital over the period. How did you compare changes in CT volume across hospitals (p-value given at the bottom of table 1)? This information needs to be added to the statistical analysis section. It is strange to present number of CTs as mean and then as a median. As discussed earlier, it would be better to consider as count data. In Table 4, no inter-quartile range is presented. The methods used to produce curves in Figures need to be described in the statistical analysis sections (LOESS). What explains the difference in curves in Figure 2 – the sharp rise in all CTs versus region specific CTs (small rise for head CTs only)? **Response: We have updates Tables 1 and 2 to include the total n over the study period. Changes across hospitals were compared using the Kruskal-Wallis test, as stated in the statistical analysis section on page 4:** **"ED CT volume reductions were determined on a per-day basis for each hospital during the COVID-19 pandemic compared to pre-pandemic, and the percentage reduction at all four sites was compared using the Kruskal-Wallis test."** **We have updated all data to be presented as medians as recommended by**

	the editors (comment E3 above). For table 4, we present the absolute total number of cases for each pathology during the study period and have added "(total)" to the column headers to clarify this. We have added the explanation for the computation of curve of best fit (LOESS) to the statistical analysis paragraph in our *Methods* section on page 4: **"Smooth curve fitting for figures was performed using local polynomial regression (LOESS)."** **R3.8.** Discussion: The first two sentences of the Discussion are appropriate for the introduction but not for interpretation. Can the authors peculate why head CT and CTPA decreased but not CTA-HN or abdomen/pelvis? Similarly, why would ureteric calculi increase during the pandemic? **Response: We have removed the first two sentences from the discussion and modified the third. We have added the following to the limitations paragraph on page 8:** **"While CTA-HN examinations did not significantly decrease during the pandemic, the absolute numbers declined, and we suspect a larger cohort would have shown a significant difference."** **We added the following paragraph to page 7:** **"It is unclear why abdomen and pelvis CT volumes slightly decreased during the pandemic however the number of patients diagnosed with new or acute pathologies increased resulting in a net higher yield for these examinations. It is also unclear why the number of patients diagnosed with ureteric calculi significantly increased (11 vs 2, P=0.0103), however it is conceivable that risk factors for development of ureteric calculi including lifestyle stress and dehydration were more prevalent during the pandemic. Future research may help clarify this observation."**