ORIGINAL ARTICLE

COVID-19 in a rural intensive care unit in Northern British Columbia: Descriptive analysis of outcomes and demands on rural resources

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Abstract

Introduction: This descriptive study reviews clinical outcomes of individuals admitted to a northern Canadian, rural intensive care unit (ICU) with severe COVID-19. It reports our site-specific data that is part of an ongoing global effort to gather data and guide therapy; the aims of this study were to describe participants admitted to our ICU with COVID-19 and illuminate challenges faced by rural and remote centres.

Methods: This retrospective study examined data from participants admitted to the ICU with COVID-19 pneumonia between 24th November 2020 and 28th February 2022. Using data from electronic and hardcopy health records, data were obtained according to standardised forms developed for the Short Period Incidence Study of Severe Acute Respiratory Infection.

Results: Eighty-five adult participants were admitted to our ICU with COVID-19. The median age of participants was 57 years old (range: 23–83 years); 49.4% were males and 50.6% were females. Of our cohort, 58.9% required mechanical ventilation at some point during their stay and the median duration of stay in our ICU was 5 days (range: 1–36 days). Amongst individuals included, 25.9% were discharged alive from our hospital on their index admission, 57.6% were transferred to another facility and 16.5% died in our facility.

Conclusion: COVID-19 significantly strained our local ICU resources, necessitating high numbers of patient transfers. However, despite limited resources, patients at our site received contemporary guideline-based care for COVID-19 pneumonia. Future pandemic and surge capacity planning must ensure that rural and remote communities receive adequate additional resources to meet the anticipated needs of their local populations.

Keywords: Cohort study, COVID-19, critical care, patient transfer, remote, rural health

Résumé

Introduction: Cette étude descriptive examine les résultats cliniques des personnes admises dans une unité de soins intensifs rurale du nord du Canada avec une

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COVID-19 sévère. Elle rapporte des données spécifiques à notre site qui font partie d'un effort global en cours pour rassembler des données et guider la thérapie. Les objectifs de cette étude étaient de décrire les participants admis dans notre unité de soins intensifs avec la COVID-19 et d'éclairer les défis auxquels sont confrontés les centres ruraux et éloignés.

Méthodes: Cette étude rétrospective a examiné les données des participants admis à l'unité de soins intensifs pour une pneumonie due à la COIVD-19 entre le 24 novembre 2020 et le 28 février 2022. Les données ont été obtenues à partir de dossiers médicaux électroniques et papier, selon des formulaires standardisés développés pour l'étude d'incidence à court terme des infections respiratoires aiguës sévères (SPRINT-SARI).

Résultats: 85 participants adultes ont été admis dans notre unité de soins intensifs avec la COVID-19. L'âge médian des participants était de 57 ans (intervalle: 23-83 ans); 49,4% étaient des hommes et 50,6% des femmes. Dans notre cohorte, 58,9% ont eu besoin d'une ventilation mécanique à un moment ou à un autre de leur séjour et la durée médiane du séjour dans notre unité de soins intensifs était de 5 jours (intervalle: 1-36 jours). Parmi les personnes incluses, 25,9% sont sorties vivantes de notre hôpital lors de leur admission initiale, 57,6% ont été transférées dans un autre établissement et 16,5% sont décédées dans notre établissement.

Conclusion: La COVID-19 a mis à rude épreuve les ressources de notre unité locale de soins intensifs, nécessitant un grand nombre de transferts de patients. Cependant, malgré des ressources limitées, les patients de notre site ont reçu des soins fondés sur des lignes directrices contemporaines pour la pneumonie due à la COVID-19. À l'avenir, la planification de la pandémie et de la capacité de pointe doit garantir que les communautés rurales et éloignées reçoivent des ressources supplémentaires adéquates pour répondre aux besoins anticipés de leurs populations locales.

Mots-clés: Étude de cohorte, COVID-19, soins intensifs, régions éloignées, santé rurale, transfert de patients

INTRODUCTION

The rural and remote, northern Canadian healthcare landscape in Canada, is affected by significant challenges including limited geographical accessibility of tertiary centres, poor coordination between health services and staffing shortages.[1-3] Health risks such as chronic health conditions including diabetes mellitus, heart disease, excess weight and chronic obstructive pulmonary disease are found at higher rates in people living in rural and remote regions.[4,5] The risk of disease and avoidable mortality increases further in rural and remote settings.[6]

In British Columbia, the rural and remote population is culturally diverse. The 2016 census found that greater than 50% of the Indigenous population of British Columbia resides in rural and small population areas.[7] Ensuring high-quality care for all, including people suffering from COVID-19 is part of health equity. By participating in the short-period incidence study of severe acute respiratory infection (SPRINT-SARI) data collection at this site, we aimed to increase rural representation in global data and examine access to and quality of healthcare in one region in rural British Columbia.

As data emerged during the COVID-19 pandemic, it was quickly noted that it was having particularly devastating impacts on certain populations. The higher prevalence of many chronic medical conditions increased the risk of severe COVID-19 in rural and remote settings.[8,9] Racialised communities were being disproportionately impacted by COVID-19 through both morbidity and mortality.[10,11] There is a lack of data describing the population of critically ill patients with COVID-19 in rural and remote Canada and this study aimed to address this knowledge gap.

METHODS

Study design and setting

This study took place in a rural intensive care unit (ICU) in Terrace, Northwestern British Columbia (unceded territory of the Tsimshian people). The 4-bed ICU served a geographic area of approximately 225,000 km^2 and a catchment of approximately 80,000 residents.[12] This ICU was funded for two critical care nurses rotating every 12 h and respiratory therapist coverage from 0700 to 1900 7 days per week. There were two resident general internists and three general internists from Southern British Columbia who provided critical care services on a rotating basis. The ICU was supported by physiotherapy services which were shared with the rest of the hospital. The

unit included one negative pressure room with antechamber and another with negative pressure capabilities; this capacity existed before the start of the COVID-19 pandemic.

Short-period incidence study of severe acute respiratory infection

We used the standardised data collection tools from SPRINT-SARI, a global collaboration of standardised research tools for COVID-19, to describe characteristics, comorbidities, outcomes and treatments provided to patients with COVID-19 in one rural ICU in northern Canada.

SPRINT-SARI is a multicentre, observational cohort study of individuals admitted to participating hospitals and ICUs with severe respiratory illnesses, including COVID-19 pneumonia.[13] It was developed in partnership with the International Severe Acute Respiratory and Emerging Infection Consortium and the World Health Organization to facilitate health research collaboration and accelerate the understanding of COVID-19 as part of the public health response to the pandemic.[13] Data were collected and managed using Research Electronic Data Capture (REDCap) tools hosted at the University of Oxford.[14,15] Early data from the national SPRINT-SARI cohort included 811 individuals from 32 hospitals with a median age of 64 (61.0% male) years and the mortality rate was 26.2%.[16]

Data sources

Data sources included health authority electronic medical records and paper charts held in health records. Retrospective chart reviews were conducted by a medical student and a nurse. Data were fully anonymised and de-identified.

Participants

This study included adult patients with a confirmed case of COVID-19, admitted to the ICU with respiratory symptoms. Data were collected for each participant on the day of admission to the hospital, day of admission to the ICU and day of discharge or transfer, according to a standardised case report form.[15] Participants excluded from this analysis included 3 paediatric cases, 5 adult cases who were readmitted with late complications after a recent ICU admission for COVID-19 pneumonia and adult cases where COVID-19 was detected incidentally without clinical signs of COVID-19 pneumonia as deemed by the clinical staff.

Statistical analysis

Descriptive statistics were used to summarise aggregated site-level data on individuals admitted to the ICU. Categorical variables were summarised in proportions and continuous variables as means with standard deviations. Analyses were performed by the analysis software embedded within the REDCap secure online research database software.

Ethics approval

This study was approved by the harmonised Research Ethics Boards for the University of British Columbia, the University of Northern British Columbia and Northern Health (REB file number: H15-02374).

RESULTS

A total of 85 participants who were admitted to the ICU with COVID-19 pneumonia between 24 November 2020, and 22 February 2022, were included in the final analysis. The median age of participants was 57 years old (range: 23–83 years); 42 (49.4%) were males and 43 (50.6%) were females. In our study population, the most common comorbidities included excess weight, hypertension and diabetes mellitus [Figure 1].

Treatment

Of the 85 participants, 50 (59.0%) required mechanical ventilation at some point during their stay. The median duration of stay was 5 days (range: 1–36 days). Non-invasive ventilation was required for 11 participants (13.0%) and high-flow nasal cannulas were used for 56 participants (66.0%), although participants may have also received high-flow nasal cannula before admission to the ICU which was not captured in this data set. To assist with ventilation, prone positioning was implemented for 48 (56.5%) of cases.

Nearly 50% (41, 48.2%) of participants required inotropic/vasopressor support. Immunomodulatory therapies were provided to 57.6% of participants (amongst these, 73.5%

received an interleukin-6 inhibitor) and 91.2% received corticosteroids. Anticoagulation, either in prophylactic or treatment doses, was provided to 82 (96.5%) participants. Treatments are summarised further in Table 1.

Complications

Complications are reported in Table 2. The most common cardiac complications in our study population were cardiac arrhythmias (14.1%) and cardiac arrest (9.4%). Other common complications included liver dysfunction (27.1%), acute kidney injury (25.9%), hyperglycaemia (22.4%), anaemia (16.5%), pulmonary embolism (15.3%) and bacteraemia (12.9%).

Outcomes

Table 3 summarises the outcomes of participants by intubation status and transfer status.

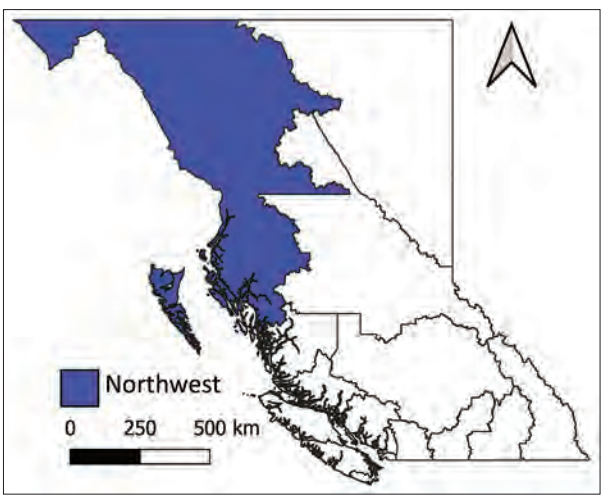

Figure 1: Prevalence of most common pre-existing comorbidities in participants admitted to our intensive care unit with COVID-19 in comparison with national data*.[16] *National data from short period incidence study of severe acute respiratory infection cohort before our data was included.

DISCUSSION

Our site's participation in this study highlights unique considerations of the impact of COVID-19 on critical care resources in rural communities.[17] Our data add an important rural and remote contribution to this dataset and increase the generalisability of the evidence generated.

Overall, the mortality in our cohort was 40.0% and the mortality rate amongst mechanically ventilated participants was 48.0%. Early analysis of other Canadian sites participating in SPRINT-SARI data collection showed a mortality rate of 31.2% amongst mechanically ventilated COVID-19 participants[16] and subsequent data estimate mortality for mechanically ventilated COVID-19 patients in Canada is 28%.[18]

Our higher mortality rate may also in part reflect the higher prevalence of comorbidities. Hypertension, diabetes and chronic cardiac disease were reported as the most prevalent presenting comorbidities of patients admitted to ICUs with COVID-19 pneumonia across Canada and worldwide [Figure 2].[16-19] Our study population had higher rates of diabetes and excess weight compared to other Canadian populations with COVID-19 [Figure 1] and reflects known geographic trends in chronic disease prevalence in rural, remote and Northern Canada.[5,6,9,16] This may have contributed to poorer COVID-19 outcomes and also highlights the importance of improving prevention, diagnosis and management of chronic disease in these regions. Our higher mortality may also reflect the limited healthcare resources in our region, distance patients must travel to receive care and mistrust in healthcare stemming from experiences of systemic racism.[20] These factors contributed to later presentation to care, delays in pre-hospital transfer, lower thresholds for capacity to be overwhelmed and delays in receiving tertiary-level

Table 1: Treatments provided to participants by ventilation status

Treatment	Intubated (*n*=50), *n* (%)	Non-intubated (*n*=35), *n* (%)	Total (*n*=85), *n* (%)
Antiviral or COVID-19 targeted treatment*	34 (68.0)	15 (42.9)	49 (57.6)
Interleukin-6 inhibitor	24 (48.0)	12 (34.3)	36 (42.4)
COVID-19 targeted agent not otherwise specified	10 (20.0)	3 (8.6)	13 (15.3)
Antibiotics	48 (96.0)	30 (85.7)	78 (91.8)
Corticosteroid	49 (98.0)	29 (82.9)	78 (91.8)
Anticoagulation	49 (98.0)	29 (82.9)	82 (96.5)
Prone positioning	33 (66.0)	15 (42.9)	48 (56.5)

*e.g. Immunomodulatory therapy such as tocilizumab and baricitinib

Table 2: Complications experienced by intubated and non-intubated participants			
Complication	Intubated (*n*=50), *n* (%)	Non-intubated (*n*=35), *n* (%)	Total (*n*=85), *n* (%)
Viral pneumonia/pneumonitis	46 (92.0)	29 (82.9)	72 (84.6)
Acute respiratory distress	42 (84.0)	7 (20.0)	49 (57.6)
Liver dysfunction	17 (34.0)	6 (17.1)	23 (27.1)
Acute renal injury/acute renal failure	14 (28.0)	6 (17.1)	22 (25.9)
Bacterial pneumonia	18 (36.0)	3 (8.6)	21 (24.7)
Hyperglycaemia	12 (24.0)	7 (20.0)	19 (22.4)
Anaemia	10 (20.0)	4 (11.4)	14 (16.5)
Pulmonary embolism	9 (18.0)	4 (11.4)	13 (15.3)
Cardiac arrhythmias	8 (16.0)	4 (11.4)	12 (14.1)
Bacteraemia	8 (16.0)	3 (8.6)	11 (12.9)
Cardiac arrest	4 (8.0)	4 (11.4)	8 (9.4)
Cardiac ischaemia	3 (6.0)	2 (5.7)	5 (5.9)
Myocarditis/pericarditis	2 (4.0)	2 (5.7)	4 (4.7)
Coagulation disorder/DIC	1 (2.0)	3 (8.6)	4 (4.7)
Myocardial infarction	2 (4.0)	1 (2.9)	3 (3.5)
Pleural effusion	2 (4.0)	1 (2.9)	3 (3.5)
Gastrointestinal haemorrhage	2 (4.0)	1 (2.9)	3 (3.5)
Congestive heart failure	0	2 (5.7)	2 (2.4)
Pancreatitis	1 (2.0)	1 (2.9)	2 (2.4)
Cardiomyopathy	0	1 (2.9)	1 (1.2)
Cryptogenic organising pneumonia	0	1 (2.8)	1 (1.2)
Endocarditis	1 (2.0)	0	1 (1.2)
Stroke/cerebrovascular haemorrhage	1 (2.0)	0	1 (1.2)
Deep vein thrombosis	1 (2.0)	0	1 (1.2)
Rhabdomyolysis/myositis	1 (2.0)	0	1 (1.2)

DIC: Disseminated intravascular coagulation

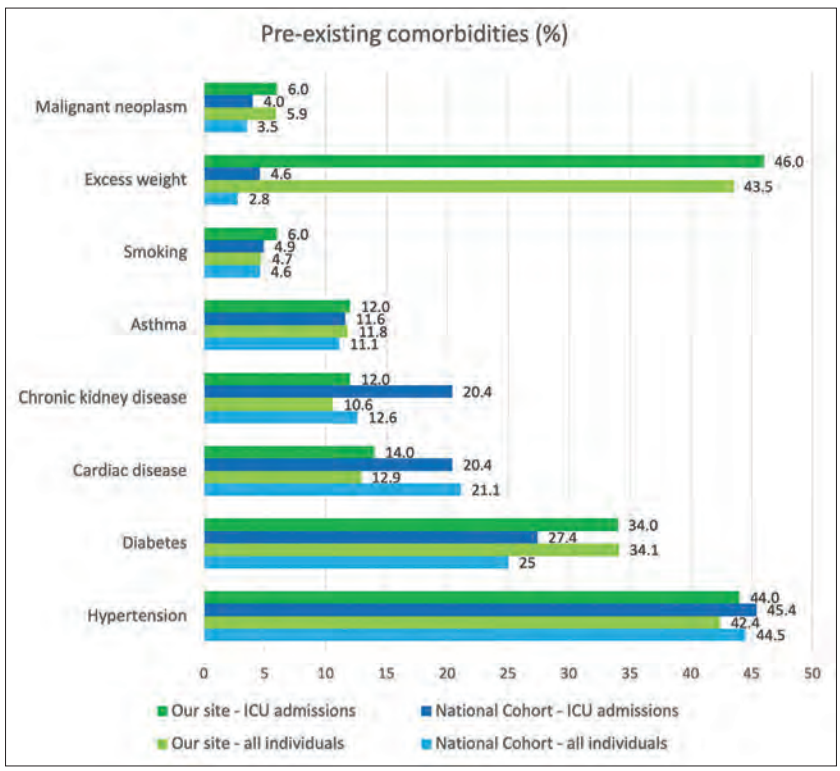

Figure 2: Prevalence of most-common pre-existing comorbidities in participants admitted to our ICU with COVID-19 in comparison with national data.

Table 3: Outcomes of participants by transfer status and intubation status

All individuals (*n*=85)			
	Non-intubated (*n*=35), *n* (%)	Intubated (*n*=50), *n* (%)	All (*n*=85), *n* (%)
Transfer to another facility	8 (22.9)	41 (82.0)	49 (57.6)
Died in our facility	9 (25.7)	5 (10.0)	14 (16.5)
Discharged alive from our facility	18 (51.4)	4 (8.0)	22 (25.9)
Ongoing hospitalisation†	0	1 (2.0)	1 (1.2)
Transfer to another facility for a higher level of care	4 (11.4)	36 (72.0)	41 (47.1)
Lateral transfer/repatriation	4 (11.4)	5 (10.0)	9 (10.6)
Died after transfer to another facility*	1 (2.9)	19 (38.0)	20 (23.5)
Total mortality	10 (28.6)	24 (48.0)	34 (40.0)
Individuals transferred to another facility (*n*=49)			
	Non-intubated (*n*=8), *n* (%)	Intubated (*n*=41), *n* (%)	All (*n*=49), *n* (%)
Higher level of care transfer	4 (50.0)	36 (87.8)	40 (81.6)
Lateral transfer/repatriation	4 (50.0)	5 (12.2)	9 (18.4)
Died*	1 (12.5)	19 (46.3)	20 (40.8)
Discharged alive	7 (87.5)	21 (51.2)	28 (57.1)
Ongoing hospitalisation†	0	1 (2.4)	1 (2.0)

*Outcome based on data that includes a review of outcomes after transfer to another facility, where available, †Outcome based on participant status at the close of study (28 February 2022)

care when indicated. In addition, early access to evidence-based therapies is particularly important for remote and rural communities that are especially vulnerable to the impacts of emerging pathogens. Further research and advocacy are needed to ensure that rural, remote and northern communities have appropriate access to critical care services.

Standardised care guidelines are often developed with an urban-centric focus and thus are difficult to implement in their entirety in rural and remote settings.[9] Our data demonstrate that despite the known disparities in rural healthcare and high-risk populations in northern and rural areas, high-quality care and evidence-based treatments can be made available to patients admitted to a rural ICU.[9,17,21] These included immunomodulatory therapy such as tocilizumab, corticosteroids and anticoagulation. Of note, only 57.6% of individuals in our study received immunomodulatory therapy; this led to a detailed review of the 42.4% of cases that did not receive immunomodulatory therapy. It was found that they were either admitted before these agents became available in our region, or clear contraindications existed in all cases except one which may have been admitted during a period of drug shortage. To further support ventilation, prone positioning was provided to 56.5% of all participants including 66.0% of mechanically ventilated participants.

Challenges

Our study draws attention to some challenges faced by one rural ICU during this demanding time. Some unique considerations for our rural setting include the low number of ICU beds, severe nurse staffing shortages, dependency on visiting nurses and non-ICU or mechanical ventilation-trained nurses.[4] In addition, limited access to members of the interprofessional team such as laboratory technicians, radiology technicians, respiratory therapists, physiotherapists and housekeeping services also contributed to the impact of the COVID-19 pandemic on our site. Known resource limitations specific to this site before the pandemic were accentuated during this time of crisis and compounded the strain in the acute care setting. An example of this was the site's ability to prone patients. Before the COVID-19 pandemic, our centre had very minimal experience proning patients and rapid development of protocols and training was needed to enable the proning of mechanically ventilated patients. Proning would commonly occur during daytime hours only, avoiding overnight proning as our site did not have respiratory therapist coverage overnight. A second example is that during some periods, we did not have access to night or weekend imaging due to technician shortages. Equitable access to

care also necessitates ensuring that ICUs in rural and remote regions are appropriately resourced to provide care during surge periods in respiratory pandemics.

The increased demand for transport systems, either for access to higher levels of care or lateral transfers for resource reasons, is also highlighted through our results. Although our patient transfer rates were high, transfers to a higher level of care accounted for 47.1% of outcomes, which means that our small rural ICU was able to provide local care for 52.9% of individuals admitted to the ICU with COVID-19 pneumonia without requiring transfer to a higher level of care. Most transfers of mechanically ventilated patients occurred as a result of exceeding local capacity to care for additional mechanically ventilated patients due to the sheer volume of cases. Earlier in the pandemic we did provide care from intubation through to extubation for patients, but as the volumes increased, we did not have sufficient staffing or physical space to meet the incoming demand. Most transfers of patients who were not mechanically ventilated or who had been liberated from mechanical ventilation were repatriated to their smaller home communities. Decisions to transfer patients were made based on multiple factors including local capacity, anticipated future health needs and transport requirements. Regional and provincial systems were established to triage patients and find accepting facilities.

For participants that did require a transfer, this meant removing critically ill people from their support systems and placing them several hundreds of kilometres away from their homes, often in an unfamiliar urban centre. This often requires the patient and family to self-fund their return trip to their community, adding considerable costs to families who have recently endured a major health crisis. Family members have important roles in care during illness including decision-making, personal care and patient safety, and this involvement is compromised in patients who are transferred far from their home communities.[22] This isolation was compounded by visiting restrictions that were aimed to reduce the transmission of COVID-19 and mitigate the demand for ICUs.[22] We found that 20 (23.5%) participants from our cohort died after a transfer, often far removed from their families, loved ones and territory. Patient and family physical and psychological outcomes relating to patient transfers that take patients far from their home communities require more research and attention.

Limitations

This study has several limitations. Our data reflect only the second and third waves as we did not have a significant first wave. Other authors have found higher mortality of COVID-19 patients admitted to the ICU in the second and third waves, so the later arrival of COVID-19 in our communities may have skewed the data.[23]

Our ICU admission days and days on mechanical ventilation are not necessarily representative of the total length of stay or days on ventilation for these patients due to the high transfer rates; our cohort was small in comparison to other urban hospitals participating in SPRINT-SARI data collection and only basic data collection was completed due to limited research capacity at the site. High-quality data on vaccine administration were not available, so analyses by vaccination status were not possible. In addition, limited local and institutional research infrastructure led to long delays from study initiation to completion. Finally, due to capacity issues, we were only able to collect data on individuals admitted to the ICU. Due to the very limited number of ICU beds, many patients who may have been in a critical care setting in some hospitals (e.g., individuals on high flow nasal cannula with high FiO2 requirements) were not included in our cohort and this may have led to a higher proportion of mechanically ventilated participants in our cohort.

CONCLUSION

Our data demonstrate that despite the known disparities in rural healthcare in northern, Canadian rural areas, such as geographical isolation, increased chronic disease burden and limited human resources in clinical settings, high-quality care and evidence-based treatments were made readily available to patients who were admitted to this ICU with COVID-19 pneumonia.[9] The increased demand for transport resources for access to higher levels of care or to offload due to staffing shortages is an important consideration for rural centres. When planning for emerging health crises, guidelines and

policies must be developed in consultation with rural and remote communities. Failure to do so leaves these communities increasingly vulnerable and amplifies geographic health inequities.

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Conflicts of interest: There are no conflicts of interest.

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