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Canadian health emergency management professionals' perspectives on the prevalence and effectiveness of disaster preparedness activities in response to COVID-19

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ABSTRACT

Emergency management (EM) professionals play an integral role in preparing healthcare organizations for disasters but evidence of their pervasiveness in Canadian healthcare is limited. Through an exploratory Canada-wide survey of EM in healthcare organizations, we aim to develop understanding of the prevalence and effectiveness of the disaster preparedness activities enacted in preparation for COVID-19. The online survey generated 161 responses; 150 (93%) had EM responsibility. EM reported that reviewing infectious disease (pandemic) plans and protocols was the most widespread activity (82%), while simulation-based exercises was the least (26%). Organizational incident management response to COVID-19 was led by a sole 'incident commander' 61% of the time, while 39% of 'incident commands' were led by multiple individuals. Of all those assigned to lead IM, only 68% received training in that role. Overall, the prevalence of disaster preparedness activities in healthcare organizations was positively associated with leaders who received training in incident response and having a dedicated EM resource. Meanwhile, the overall effectiveness of activities was positively correlated with having a sole 'incident commander' and was found to improve as the overall prevalence of activities rose. The study provides strong evidence for regional, organizational, and EM resource variation in the delivery of disaster preparedness activities and training for leaders in Canadian healthcare. Hence, we recommend the creation of a national health emergency preparedness system which includes legislated standards and a national training centre to ensure Canadian healthcare is bolstered against future disasters including pandemics.

1. Introduction

[1]Coronavirus disease (COVID-19), caused by severe acute respiratory syndrome coronavirus (SARS-CoV-2) was declared a pandemic by the World Health Organization (WHO) in March 2020 [1] and as of April 2021, has infected over 132 million and claimed more than 2 million lives [2]. As of May 2021 Canada has 1,305,770 cases with 64,802 hospitalizations and 24,766 deaths [3]. Prior to the COVID pandemic the Canadian Health System was already under immense pressure to provide equitable access to coordinated care, notably specialist and elective surgical services [4]. As news coming out of China became more difficult to ignore and cases were detected internationally in early 2020, public health entities and epidemiological experts within Canada started sounding the alarm. In healthcare organizations preparedness activities intensified as cases appeared in the Toronto area.

Evidence soon showed widespread community transmission within most Canadian provinces. As a result, efforts related to planning and preparedness quickly shifted to response with case counts rising rapidly. By March 22nd all Canadian provinces and territories had declared states of emergency [5]. Provincial health systems struggled to provide consistent guidance to health providers and services were constricted to focus efforts on building capacity for anticipated COVID-19 patients. Canada's ability to mount a coordinated and standardized response to national health crisis suffers from untested emergency management plans and struggles over jurisdictional issues [6,7]. As a result, many healthcare organizations in Canada remain chronically un-prepared for

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[1] Abbreviations: Emergency Management (EM), Incident Management (IM), Incident Command (IC), Coronavirus Disease (COVID-19).

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potential disasters, including global pandemics [8]. While evidence for the impact of COVID-19 on hospital services and operations, including switching to virtual care delivery models, are beginning to emerge [9], what remains unclear is just how effective, and wide-spread, were emergency preparedness activities undertaken by healthcare organizations in the response to COVID-19.

Emergency management (EM) professionals help organizations prepare for potential disasters and emergencies. Planning for pandemics and infectious disease hazards represents one of several core EM activities undertaken to enhance preparedness. Typically, emergency management professionals build an organization's preparedness through the development of rigorous plans and protocols, making them available for all healthcare staff in the event of emergencies. This extends to the training of leaders of health organizations in the principles of emergency response. Additionally, these resources are charged with adapting an incident management system, notably the Hospital Incident Command System, to their organization and training key individuals for incident response and working within the Emergency Operations Centre (EOC).

Further, conducting exercises, ranging from table-top to full-scale simulations involving role-play and mock-patients, is another EM activity critical to ensuring health organizations are prepared for any crisis. These activities are part of the health emergency preparedness framework as described by Khan et al. [10], in Canada. Khan et al. further expand this framework and include considerations for governance and system leadership, multi-agency collaboration, planning activities, practice and experience (including simulation), and resource allocation. While guidance for a resilient and prepared health system is outlined the operationalization of these activities, association between them, and how they interact to build preparedness is not fully understood [11].

To the best of our knowledge there is no study which assesses the prevalence and effectiveness of disaster preparedness activities across healthcare organizations in Canada during a Pandemic. While some success has been achieved in response to the Accreditation Canada Survey and in the assessments of hospital preparedness [11,12] there is no standard tool for assessment [13]. The dearth of evidence for the effectiveness and prevalence of emergency management in health is not unique to Canada. The scoping study by Lee et al. [14], of the internationally published academic literature found it was unclear whether health organizations were integrated in their response to emergencies, and whether they functioned effectively as a system. Health emergency management during a public health crisis, like the global COVID-19 pandemic, is a unique event that has not been experienced by most EM professionals [15]. The aim of this study is to determine the prevalence and effectiveness of disaster preparedness activities in Canadian healthcare organizations during the COVID-19 pandemic. We achieve this aim, through an exploratory Canada-wide survey of emergency management (EM) professionals in healthcare organizations.

2. Emergency management in healthcare

In the past 20 years there has been greater recognition for the need to employ dedicated professionals to build a comprehensive emergency management program based on the increasing frequency intensity and duration of disasters such as floods, wildland fires and infectious disease outbreaks [16]. As Blake et al. [17]; p. 359) specify health EM practitioners are *"integral to a country's emergency management infrastructure"*. Furthermore, these personnel lead organizations in preparation for potential disasters and emergencies which includes a myriad of preparedness activities and often involves planning for pandemics and infectious disease hazards [18,19]. Despite the recognized need for EM expertise to mitigate crises such as floods, hurricanes, terrorist events, the integration of EM during the pandemic remained largely underutilized [20].

The EM professional in Canadian healthcare organizations is a role that is still not widely understood by hospital leadership [21] and, from a research perspective, is a group that has received little exposure. Part of the challenge is that Healthcare EM are historically tied to a compliance function ensuring healthcare organizations met codes, legislative requirements and, later on, accreditation standards in Canada. While progress has been made on raising awareness of emergency management, their success largely rests on the EM professional's abilities and the commitment of hospital leadership to the program. Complicating matters, EM professionals are not always a full-time dedicated resource in health organizations, they may hold additional workplace responsibilities, including other administrative and clinical roles. Impediments to the professionalization of the role including lack of professional competencies [22], standards of business delivery, higher education [23] and consistent approaches to preparedness activities [11], amongst others. While Canadian provinces with legacies of ongoing disaster response do place a priority on health emergency management, such as in Alberta with a history of fires and floods in the last twenty years, the EM capability across all regions is not uniform. Further, there is a compliance aspect to integrating EM as part of healthcare operations. Hospitals seeking certification by Accreditation Canada, for example, would involve compliance with that organization's guidance for Emergency and Disaster Management Programs.

2.1. Disaster preparedness activities in health organizations

Preparedness is the capacity to respond to the health needs of the pandemic-affected population and the ability to stay operational under critical conditions when demand for care and the availability of time and resources are scarce [11]. Various tools and guides have been developed for hospitals when COVID-19 preparation was being considered. These were largely aimed at surge management [24,25], ICU capacity [26], using simulation [27], hospital management [28] and the Centre for Disease Control hospital preparedness checklist [29].

The preparedness activities included in our exploratory survey reflect a comprehensive approach to developing emergency preparedness in healthcare organizations grounded in the works of Verheul & Dückers [11]; Dobalian et al., [12]; Kaji et al., [13]; and Accreditation Canada [30]. The activities are as follows: 1) infectious disease (pandemic) plans and protocols, 2) donning and doffing personal protective equipment, 3) table-top and 4) simulated exercises 5) activating Incident Management, 6) training for multi-agency response 7) setting up physical and 8) virtual emergency operations centres, and 9) clinical management strategies.

2.1.1. Infectious disease plans and protocols

Planning for infectious disease threats represent a core EM activity. Traditional "pandemic planning" was based on overarching federal and provincial plans and at the organizational level included clinical management, contingency planning, workforce reductions, infection and prevention control activities, and the use of alternate care sites, to name a few. Despite increased awareness caused by the SARS outbreak [31], organizational infectious disease plans are thought to be of limited effectiveness and too specific to the influenza family of viruses [32]. This is because many are outdated and do not reflect up-to-date changes in hospital lay-outs, clinical service delivery, and information technology & services. A uniform benefit is unlikely as plans often vary considerably [33]. Further, previous pandemic planning did not account for the operational, financial, and political complexities [34] that COVID-19 brought forth. Compounding this many health organizations had not recently tested their pandemic plans [35]. The activity measure included whether plans and protocols were reviewed and strengthened prior to the declaration of the emergency.

2.1.2. Donning and doffing personal protective equipment (PPE) training

Donning and doffing training, where healthcare staff physically equip PPE, is vital to ensuring staff and patients alike are protected from disease transmission. Throughout the pandemic in Canada personal

protective equipment (PPE) was a finite and scarce resource [36]. When healthcare workers are competent in donning and doffing PPE, they feel safer and the spread of infection is less likely [37]. The activity measure includes whether donning and doffing PPE training was conducted prior the declaration of the emergency.

2.1.3. Table-top and simulation based exercises

Healthcare staff who took part in simulated exercises reported feeling significantly better prepared to respond to major incidents when compared to their peers who did not participate [38]. Furthermore, specific disease related training for novel pathogens increased the confidence and perceived ability of emergency department staff to clinically manage care [39]. This activity measure differentiates between table-top only and simulation exercises involving live role play, for example, conducting drills with simulated patients, prior the declaration of the emergency.

2.1.4. Activating incident management (IM)

Healthcare organizations across Canada use a systematic approach in responding to emergencies. While there is some variation in the systems used, the overarching goal is to manage the response effectively. While the terminology varies, such as Incident Management System (IMS), and Hospital Emergency Incident Command System (HEICS), we refer to the term Incident Management (IM). IM structure clarifies both roles and responsibilities for each "incident position" as well as a reporting structure that is scalable to the response required [40]. Although healthcare organizations are thought to be slow in activating the IM structure [41], the value of using IM in healthcare is found to have numerous benefits including alleviating pressure on emergency departments [42]. In terms of the role "incident commander" (IC), an individual leader from the healthcare organization must be appointed to lead the overall emergency operations response. Multiple commanders might be appointed if the duration and intensity demand it. Typically, within a healthcare organization a sole medical or non-medical leader would assume this command role and receive support by EM personnel. As a best practice, leaders appointed to IC must undergo training in that role, which allows them to effectively manage an incident, even as long term as COVID-19 [43]. The activity measure we explore is whether IM has been activated prior declaration of the emergency, who was appointed to lead the IM during the emergency, and whether that IC individual(s) received training in incident management.

2.1.5. Training for multi-agency response

Given that incidents are often complex and require interdisciplinary and multijurisdictional co-ordination, preparing for response between agencies and levels of government is crucial. Given the wide-spread nature of the pandemic, numerous groups within the health system, including public health entities and other potential partners such as those at the municipal, provincial, or federal level require working together. The activity measure we look at is whether exercises occurred between the health organizations and other agencies prior to the declaration of the emergency.

2.1.6. Setting up a physical or setting up a virtual emergency operations centre (EOC)

An emergency operations centre (EOC) serves as the logistical and operational arm of the Incident Management (IM) system [44]. Within a health organization, the EOC might include representation of personnel from a range of specialties and system partners to maintain situational awareness and allow for the deployment of health care resources as deemed necessary by incident command. The EOC functions as the organization's authoritative channel during the emergency response. For this activity measure we differentiate between whether the EOC was enacted physically, where personnel met together in the same physical space, and/or whether they met virtually using technology such as video conferencing prior to the declaration of the emergency.

2.1.7. Clinical management strategies

Clinical management strategies are extensive and varied in nature. The activity measure in our survey involves activities around surge planning, isolation capacity requirements, and critical care capability. While surge planning is a core activity, it must be aligned with a systems-thinking, multi-agency perspective or risk creating unintended harm elsewhere in the system. For example, in the United Kingdom, creating hospital surge capacity in the early part of the pandemic saw large scale discharges from hospitals of infected patients back to long-term care home sector where infection control measures were not optimal, seeding infections into vulnerable settings [45].

3. Methods

3.1. Study design and measures

Based on literature review, discussions with emergency management (EM) experts, and pilot testing with 15 EM professionals from across Canada, we developed an 8-minute online survey. Ethical approval was obtained through the Ethics Review Committee at the University of Sheffield, United Kingdom. The survey, available in both English and French, was first distributed in November 2020 through EM contacts in each province using a snow-ball sampling method. Next, through December 2020 to January 2021 the survey was distributed through the Canadian College of Health Leaders (CCHL) to its 4000 plus members. CCHL membership consists of Canadian health leaders, including those responsible for hospitals, long-term care facilities, and other health organizations in every Canadian province and Territory. We asked that the survey was completed by individuals with EM responsibility in each members' organization. Respondents had varying degrees of EM responsibility which we classified as sole (core EM duties), primary (majority of week spent performing EM duties), secondary (majority of week spent performing other duties), or emergent (you were seconded to perform EM duties related to COVID-19). Regional and organizational characteristics of respondents were gathered in line with the Canadian Institute for Health Information peer group methodology [46]. Specifically, whether the respondent worked for a small, medium, or large health organization, and whether that organization was academically affiliated was collected. Major topics covered by the survey include what disaster preparedness activities were undertaken prior to the declaration of emergency, and the effectiveness of those activities in responding to COVID-19.

We expected that health organizations which had a greater prevalence of disaster preparedness activities conducted prior to declaration of the emergency would have greater number of leaders trained in incident management (IM), emergency managers with sole responsibilities, and be academically affiliated. In turn, we expected that composite scales of these variables would be positively associated with greater effectiveness of disaster preparedness activities.

3.2. Composite scales

3.2.1. Prevalence score

Key to effective emergency management are preparedness activities which if undertaken can help develop an organizations disaster preparedness capability. We developed a nine-item index; pandemic plan review, training for multi-agency response, activating IM, setting up physical and virtual EOC, Scenario planning (whether table-top or simulation based exercises), donning and doffing PPE training, and clinical management strategies (e.g. Surge capacity development). Respondents were given one point for each of the nine items that were checked with a "yes", so the overall scale ranged from 0 to 9. Cronbach's alpha reliability coefficient for the scale was 0.73.

3.2.2. Effectiveness score

Each respondent was asked to rate the effectiveness of each disaster preparedness activity. Answering whether 'This activity was useful in preparing for COVID-19' respondents provided their perception of effectiveness on a 5-point likert scale, ranging from strongly disagree to strongly agree. An overall effectiveness score, ranging from 1 to 5, was calculated using the mean of all activity effectiveness ratings for each respondent. Cronbach's alpha reliability coefficient for the scale was 0.87.

3.2.3. IM leadership and training scores

Non-emergency management leaders (e.g CEOs, VPs, Medical Directors) in health organizations are often called to lead during an emergency. The number of leaders assigned to lead IM ranged from 1 to 5 in the Incident Command (IC) role from the onset of COVID through to when the survey was completed. Their professional background (whether non-medical leader, medical leader, subject matter expert, emergency management, or other) was recorded. We aimed to assess whether these leaders were provided training in the principles of incident management. The training score was calculated by dividing the number of leaders trained by the total number of leaders assigned to the IM team (ranging from 0 to 100%).

4. Data analysis

We began our analysis by computing descriptive statistics using STATA 16.1 to present the findings on each variable and summary scales of interest. We used a separate Kruskal-Wallis H Test for each background characteristics (regional, organizational, EM responsibility, IM leadership, IM training) to determine if there were statistically significant differences between sub-group means by disaster preparedness activity prevalence and effectiveness. Chi-squared with ties and P values are reported for each subgroup where significance at 95% confidence level or better was found. Due to the non-normal distribution and Likert-ranking of the data, we also conducted Kendall Tau correlations on EM activity prevalence and the Likert-type variable EM activity effectiveness (see Appendix).

We used multivariable regression analysis to assess the relationship between the prevalence score (dependent) and training score, organization size, academic affiliation, EM responsibility, and IM Leadership. We also ran a second regression using the effectiveness score (dependent), and training score, prevalence score, organization size, academic affiliation, EM responsibility, and IM Leadership. Regression was run twice for each score, once with a fixed effect to account for regional variation and once without.

5. Results

Table 1 shows the respondents background characteristics. A total of 161 respondents completed the survey. 11 respondents were not included in our data because they indicated *'I don't have emergency management responsibilities'*, leaving 150 responses by emergency managers working in Canadian healthcare organizations. The provinces with the highest participation include Ontario (49%), Alberta (17%), British Columbia (13%) and Newfoundland and Labrador (6%). 43% of respondents were from large healthcare organizations with more than 10,000 staff, 79% worked for organizations in metropolitan areas, and most respondents (72%) worked for organizations that are academically affiliated. In terms of resource dedication (how specific to EM) 20% were sole, another 20% were primary, 39% were secondary EM, while 21% were emergent-dedicated in relation to COVID-19. With regards to those professionals who led incident management response in each organization, 39% by a multi-professional team, 38% by a sole non-medical leader, 12% by a sole medical leader, 5% by a sole emergency manager and another 5% were led by a sole subject matter expert (e.g. infectious disease specialist).

Table 1
Respondents background characteristics.

Characteristics	N[a]	%
Province		
Alberta	25	17%
British Columbia	19	13%
Manitoba	2	1%
New Brunswick	5	3%
Newfoundland and Labrador	9	6%
Northwest Territories	1	1%
Nova Scotia	3	2%
Ontario	74	49%
Prince Edward island	2	1%
Quebec	4	3%
Saskatchewan	5	3%
Yukon	1	1%
Total	150	100%
Organization Size		
Small (1–1000)	41	27%
Medium (1001–10,000)	44	29%
Large (10,000+)	65	43%
Total	150	100%
Organization Academically Affiliated		
Yes	101	72%
No	40	28%
Total	141	100%
Organization Population Catchment		
Metro (at least 50,000)	118	79%
Micro (between 10 and 50 k)	11	7%
Rural	21	14%
Total	150	100%
Emergency Management Responsibility		
Sole	30	20%
Primary	30	20%
Secondary	59	39%
Emergent	31	21%
Total	150	100%
Incident Management Leadership		
Sole Non-Medical Leader	56	38%
Sole Medical Leader	18	12%
Sole Emergency Manager	7	5%
Sole Subject Matter Expert	8	5%
Multi-led team	57	39%
Total	146	100%

[a] Total N varies because of incomplete responses.

5.1. Overall emergency preparedness activity prevalence and effectiveness

Table 2 shows the descriptive statistics on all the variables of interest. With regards to the prevalence of activities prior to the declaration of an emergency, pandemic planning was the most prevalent (82%) while simulation-based exercises were the least (26%). The prevalence score indicated that on average EM enacted 5 out of 9 preparedness activity, while the standard deviation of 2.36 suggests the actual number of activities enacted was quite variable in the population. The activity which ranked as most effective was donning and doffing PPE (4.6 of 5), while the least effective activity was reviewing pandemic plans (4.07 of 5). Overall, the mean effectiveness score was 4.28 of 5. This total effectiveness score shows that overall, respondents agreed that each of the disaster preparedness activities they implemented were effective at preparing their organization for the response to COVID-19. The median number of professionals which led each organizations' IM response was one, while the maximum reported was five. The percentage of those who led IM response and were trained in their roles was 68%. The variables which influence prevalence and effectiveness scores will be assessed in the multivariable regression.

Table 2
Descriptive statistics on study variables.

Summary Statistics							
Variable	N	% (n/150)	Mean	sd	min	median	max
Activity Effectiveness							
Pandemic Plan Review	122	82	4.07	0.97	1	4	5
Donning and doffing PPE training	112	75	4.61	0.76	1	5	5
Activating IM	108	73	4.39	0.85	1	5	5
Clinical management strategies	91	61	4.44	0.76	1	5	5
Setting up physical EOC	79	53	4.20	0.91	1	4	5
Training for multi-agency response	73	49	4.32	0.78	1	4	5
Table-top only scenario planning	70	47	4.16	0.81	2	4	5
Setting up virtual EOC	68	46	4.49	0.82	1	5	5
Simulation Based Exercises	38	26	4.32	0.77	3	4.5	5
IM Leadership Team Size (1–5)	150	1	1.68	1.03	1	1	5
Training Score (0–1)	150	1	0.68	0.42	0	1	1
Prevalence Score (0–9)	150	1	5.13	2.36	0	5	9
Effectiveness Score (1–5)	150	1	4.28	0.70	1	4.3	5

5.2. Prevalence of disaster preparedness activities in Canadian health organizations

The prevalence of preparedness activities in Canadian healthcare organizations as reported by emergency managers is found in Table 3. These variables are presented by panel A and B. Panel A: regional and organizational characteristics, and panel B: emergency management and leadership characteristics. Kruskal-Wallis H tests were run for each subgroup (Region, Organization Size, Academic Affiliation, EM responsibility, IM leadership, IM training) to determine the statistical significance between subgroup means. While regional sample sizes are unequal, the chi-square value computed from Kruskal-Wallis test takes accounts for this, comparing actual frequencies of combinations vs the frequencies expected under the null hypothesis. We assigned responses to a fourth region called 'Atlantic', comparable to Ontario, Alberta, and British Columbia. Atlantic consists of the responses of EM from the provinces: New Brunswick, Prince Edward Island, Nova Scotia, and Newfoundland and Labrador. This categorization reflects inter-provincial emergency response measures known as the 'atlantic bubble', adopted to limit travel and contain infection during the first wave [47]. Exploring each preparedness activity by panel A and B characteristics we found statistically significant difference in their prevalence, only these are listed next.

5.2.1. Activating incident management

Activating IM varied by region, $\chi2(2) = 12.749$, $p = 0.0052$, with a mean rank prevalence of 95% for Atlantic, 84% for Alberta, 74% for Ontario, and 47% for British Columbia (BC). Large and medium organizations, tied at 82%, were more likely to have activated their IM, $\chi2(2) = 19.576$, $p = 0.0001$, than small organizations at 45%. Whether an organization was academically affiliated or not, also saw a difference in the mean prevalence, $\chi2(2) = 19.752$, $p = 0.0001$, at 84% and 48% respectively. Activating IM also varied by emergency management responsibility, $\chi2(2) = 7.926$, $p = 0.0476$, with 87% for primary, 83% for sole, 66% for secondary, and 61% for emergent.

5.2.2. Training for multi-agency response

The prevalence of training for multi-agency response differed by region, $\chi2(2) = 9.007$, $p = 0.0292$, at 72% for Alberta, 68% for Atlantic, 43% for Ontario, and 42% for BC.

5.2.3. Donning and doffing personal protective equipment training

Atlantic and Alberta both reported 84% prevalence of donning and doffing PPE training ($\chi2(2) = 10.774$, $p = 0.0130$) while Ontario and BC reported 79% and 47% respectively.

5.2.4. Clinical management strategies

The prevalence of clinical management strategies, $\chi2(2) = 14.647$, $p = 0.0021$, was 89% in Atlantic, 84% in Alberta, while Ontario and BC both reported 53%.

5.2.5. Setting up virtual emergency operations centre

Prevalence of setting up virtual EOC, $\chi2(2) = 11.259$, $p = 0.0036$, was 61% in large organizations, 36% medium, and 33% small. Whether an organization was academically affiliated or not, also saw a difference in the mean prevalence, $\chi2(2) = 5.783$, $p = 0.0162$, at 52% and 30% respectively. Setting up virtual EOC also varied by emergency management responsibility, $\chi2(2) = 9.009$, $p = 0.0292$, at 63% for sole, 58% for emergent, 37% for primary, and 36% for secondary.

5.2.6. Setting up physical emergency operations centre

Prevalence of setting up physical EOC, $\chi2(2) = 7.912$, $p = 0.0191$, was 64% in large organizations, 52% in medium, and 35% in small.

5.2.7. Table top only scenario planning

Prevalence of table top only scenario planning, $\chi2(2) = 6.506$, $p = 0.0387$, was 59% in medium organizations, 46% in large, and 30% in small. Whether an organization was academically affiliated or not, also saw a difference in the mean prevalence, $\chi2(2) = 5.014$, $p = 0.0251$, at 53% and 33% respectively. Prevalence also varied by IM Leadership, $\chi2(2) = 7.252$, $p = 0.0071$, with 61% for multi-led and 39% for sole-led IM. Whether IM leaders were trained was also a significant factor in prevalence of table top planning, $\chi2(2) = 12.876$, $p = 0.0016$, with some leaders trained at 64%, all leaders trained at 53%, and no leaders trained at 22%.

5.2.8. Simulation based exercises

Whether an organization was academically affiliated or not, saw a difference in the mean prevalence of simulation exercises, $\chi2(2) = 4.823$, $p = 0.0897$, at 32% and 13% respectively. Prevalence also varied by IM Leadership, $\chi2(2) = 5.580$, $p = 0.0182$, with 37% for multi-led and 19% for sole-led IM.

5.3. Effectiveness of disaster preparedness activities in Canadian health organizations

The effectiveness of disaster preparedness activities in Canadian healthcare organizations as reported by emergency managers is reported in Table 4. These variables are presented by panel B characteristics, as there were no statistically significant differences in effectiveness by panel A characteristics.. Kruskal-Wallis H tests were run for each subgroup to determine the statistical significance between subgroup

Table 3
Prevalence of emergency preparedness activities in Canadian health organizations.

Panel A: Regional and Organizational Characteristics

Activity Prevalence	mean	Regions				Organization Size			Academic Affiliation	
	Total (N = 150)	AB (n = 25)	ON (n = 74)	BC (n = 19)	ATL (n = 19)	Small (n = 40)	Medium (n = 44)	Large (n = 61)	Yes (n = 101)	No (n = 40)
Pandemic Plan Review	0.82	0.84*	0.86*	0.63*	0.89*	0.8*	0.84*	0.82*	0.85	0.78
Training for multi-agency response	0.49	0.72**	0.43**	0.42**	0.68**	0.4	0.59	0.48	0.51	0.43
Activating IM	0.73	0.84***	0.74***	0.47***	0.95***	0.45***	0.82***	0.82***	0.84***	0.48***
Setting up physical EOC	0.53	0.68	0.53	0.42	0.58	0.35**	0.52**	0.64**	0.60*	0.4*
Setting up virtual EOC	0.46	0.64*	0.45*	0.26*	0.53*	0.33***	0.36***	0.61***	0.52**	0.3**
Table-top only scenario planning	0.47	0.4	0.51	0.47	0.53	0.3**	0.59**	0.46**	0.53**	0.33**
Simulation Based Exercises	0.26	0.28	0.27	0.26	0.26	0.15	0.25	0.31	0.32**	0.13**
Donning and doffing PPE training	0.75	0.84**	0.79**	0.47**	0.84**	0.83	0.8	0.69	0.78	0.75
Clinical management strategies	0.61	0.84**	0.53**	0.53**	0.89**	0.63	0.5	0.67	0.66*	0.5*

Panel B: Emergency Management and Leadership Characteristics

Activity Prevalence	mean	Emergency Management Responsibility				IM Leadership		IM leads trained in their roles		
	Total (N = 150)	Sole (n = 30)	Primary (n = 30)	Secondary (n = 59)	Emergent (n = 31)	Sole-Led (n = 93)	Multi-led (n = 57)	All (n = 89)	Some (n = 25)	None (n = 36)
Pandemic Plan Review	0.82	0.87	0.87	0.81	0.74	0.78	0.88	0.83	0.88	0.75
Training for multi-agency response	0.49	0.57	0.57	0.46	0.42	0.46	0.54	0.51	0.52	0.44
Activating IM	0.73	0.83**	0.87**	0.66**	0.61**	0.72	0.74	0.78	0.64	0.67
Setting up physical EOC	0.53	0.73*	0.57*	0.46*	0.45*	0.53	0.54	0.57	0.56	0.42
Setting up virtual EOC	0.46	0.63**	0.37**	0.36**	0.58**	0.43	0.51	0.52	0.44	0.33
Table-top only scenario planning	0.47	0.53	0.5	0.46	0.42	0.39***	0.61***	0.53***	0.64***	0.22***
Simulation Based Exercises	0.26	0.4	0.33	0.19	0.19	0.19**	0.37**	0.28	0.32	0.17
Donning and doffing PPE training	0.75	0.63	0.87	0.78	0.71	0.73	0.79	0.74	0.76	0.78
Clinical management strategies	0.61	0.7	0.67	0.58	0.55	0.62	0.6	0.66	0.44	0.61

Statistical Significance of the differences between subgroup means at the 10%, 5% and 1% levels are denoted by *, **, ***, respectively (Kruskal-Wallis H test). Total N may vary due to skipped questions.

means. Activity effectiveness is reported as the mean Likert score (minimum 1 'strongly disagree' to maximum 5 'strongly agree') followed by the standard deviation.

Reviewing activity effectiveness by panel B characteristics shows the following statistically significant differences in mean scores.

5.3.1. Pandemic plan review

The effectiveness of pandemic plan review was found to vary by IM leadership, $\chi2(2) = 6.298$, $p = 0.0121$, with 4.23(0.89) for sole-led and 3.82(1.03) for multi-led. Whether leaders were trained on incident management was also a significant factor in the effectiveness of pandemic plans, $\chi2(2) = 8.390$, $p = 0.0151$, when all leaders were trained at 4.26(0.87), some leaders 3.91(0.92), and none 3.67(1.14).

5.3.2. Activating IM

The effectiveness of activating IM was found to vary by IM Leadership, $\chi2(2) = 4.931$, $p = 0.0264$, with 4.51(0.8) for sole-led and 4.2(0.9) for multi-led.

5.3.3. Setting up virtual emergency operations centre

Whether leaders were trained was a significant factor in how effective setting up a virtual EOC was, $\chi2(2) = 8.359$, $p = 0.0153$, when some leaders were trained at 4.73(0.47), all trained at 4.58(0.75), and none trained at 3.92(1.08).

5.3.4. Simulation based exercise

Whether leaders were trained was a significant factor in the effectiveness of simulation exercises, $\chi2(2) = 7.468$, $p = 0.0239$, when all

Table 4
Effectiveness of emergency preparedness activities in Canadian health organizations.

Panel B: Emergency Management and Leadership Characteristics

Activity Effectiveness	m(sd)	Emergency Management Responsibility				IM Leadership		IM Leads trained in their roles		
	Total (N = 150)	Sole (n = 30)	Primary (n = 30)	Secondary (n = 59)	Emergent (n = 31)	Sole-Led (n = 93)	Multi-led (n = 57)	All (n = 89)	Some (n = 25)	None (n = 36)
Pandemic Plan Review	4.07(0.97)	3.92(1.12)	4.12(0.91)	4.25(0.76)	3.78(1.2)	4.23(0.89)**	3.82(1.03)**	4.26(0.87)**	3.91(0.92)**	3.67(1.14)**
Training for multi-agency response	4.32(0.78)	4.5(0.63)	4.06(0.97)	4.3(0.67)	4.46(0.88)	4.4(0.79)	4.2(0.76)	4.36(0.72)	4.23(0.6)	4.25(1.06)
Activating IM	4.39(0.85)	4.25(0.99)	4.5(0.91)	4.51(0.6)	4.16(1.01)	4.51(0.8)**	4.2(0.9)**	4.5(0.78)	4.19(0.66)	4.21(1.1)
Setting up physical EOC	4.2(0.91)	4.1(0.83)	4.35(1.06)	4.3(0.72)	4(1.18)	4.24(0.92)	4.13(0.9)	4.34(0.89)*	4(0.88)*	3.93(0.96)*
Setting up virtual EOC	4.49(0.82)	4.56(0.62)	4.36(1.21)	4.57(0.6)	4.39(0.98)	4.45(0.78)	4.54(0.88)	4.58(0.75)**	4.73(0.47)**	3.92(1.08)**
Table-top only scenario planning	4.16(0.81)	4.13(0.99)	4.13(0.74)	4.19(0.74)	4.15(0.9)	4.19(0.79)	4.12(0.84)	4.26(0.74)	3.94(1.06)	4(0.53)
Simulation Based Exercises	4.32(0.77)	4.36(0.81)	4.1(0.88)	4.64(0.5)	4(0.89)	4.56(0.7)*	4.1(0.79)*	4.58(0.58)**	4(0.93)**	3.67(0.82)**
Donning and doffing PPE training	4.61(0.76)	4.56(0.98)	4.62(0.85)	4.67(0.52)	4.5(0.91)	4.62(0.79)	4.59(0.73)	4.71(0.63)*	4.74(0.45)*	4.29(1.08)*
Clinical management strategies	4.44(0.76)	4.45(1)	4.3(0.98)	4.53(0.56)	4.41(0.51)	4.47(0.71)	4.39(0.86)	4.45(0.71)	4.73(0.65)	4.27(0.94)

Statistical Significance of the differences between subgroup means at the 10%, 5% and 1% levels are denoted by *, **, ***, respectively (Kruskal-Wallis H test). Total N may vary due to skipped questions.

leaders were trained at 4.58(0.58), some trained at 4(0.93), and none trained at 3.67(0.82).

5.4. Disaster preparedness activity correlations

Two Kendall's tau-b correlations were run to determine the association between the nine preparedness activities (See Appendix). The first correlation examined activity prevalence while the second examined activity effectiveness. In each correlation table, the Tau-b score (τb) and significance value is reported at the intersection of each activity. τb is reported between −1 (a perfect negative monotonous relation), 0 (no relation), and +1 (a perfect positive monotonous relation). Here we delineate activities by positive correlations in effectiveness which reveal potential synergistic effects. Simulation based exercise was found to have a statistically significant and strong positive correlation with the effectiveness of two other activities: training for multi-agency response and activating IM. Further, where simulation was utilized, there was a positive correlation with the prevalence of six of the other eight activities which were statistically significant, excluding donning and doffing PPE, and clinical management strategies. Donning and doffing PPE training had a statistically significant and positive correlation with the effectiveness of both activating IM and setting up virtual EOC. Table-top scenario planning was also strongly and positively correlated with the effectiveness of virtual EOC.

5.5. Prevalence and effectiveness scores multivariable regression

Table 5 shows the results for the multivariable regression of prevalence and effectiveness scores on several characteristics including organizational, EM responsibility, and IM leadership and training. While regional samples are unequal, a fixed effect was added to the regression to control for regional background characteristics. We excluded 22 respondents who had missing data for the regression variables. The largest sample for the regression was 128 responding emergency managers which had complete data. Dummy variables were created for EM responsibility: primary, secondary, and emergent – compared to the reference group: sole. Several different specifications of the model were run, such as additional dummy variables, and adding and removing

Table 5
Regression model results.

Variables	Prevalence Score	Prevalence Score (w/fixed effect)	Effectiveness Score	Effectiveness Score (w/fixed effect)
Prevalence Score	–	–	0.07** (0.03)	0.07** (0.03)
Training Score	0.92** (0.45)	0.92** (0.45)	0.28** (0.14)	0.26* (0.14)
Organization Size	0.08 (0.31)	0.05 (0.32)	0.06 (0.09)	0.04 (0.10)
Academic Affiliation: Yes	1.01* (0.53)	0.98* (0.52)	−0.27 (0.16)	−0.27 (0.17)
EM Responsibility: Primary	−0.42 (0.67)	−0.48 (0.66)	0.15 (0.20)	0.17 (0.20)
EM Responsibility: Secondary	−1.21** (0.59)	−1.16** (0.58)	0.32* (0.18)	0.32* (0.18)
EM Responsibility: Emergent	−1.44** (0.62)	−1.48** (0.61)	0.13 (0.19)	0.14 (0.19)
IM Leadership: Sole led	−0.47 (0.41)	−0.49 (0.41)	0.27** (0.12)	0.25** (0.13)
Constant	5.00*** (0.97)	5.09*** (0.98)	3.46*** (0.32)	3.53*** (0.33)
Observations	128	128	127	127
R-squared	0.18	0.23	0.14	0.16
Province Fixed Effect	No	Yes	No	Yes

Standard errors in parentheses.
***p < 0.01, **p < 0.05, *p < 0.1.

other characteristics did not substantively change the results.

5.5.1. Prevalence score

Looking at the prevalence score, training score and EM responsibility are found to be significantly associated. Training score was positively correlated with prevalence score; while Secondary and Emergent EM were negatively correlated with prevalence score. Prevalence score is lower for secondary and emergent EM than for sole EM. Neither organization size nor IM leadership were significantly correlated with prevalence score.

5.5.2. Effectiveness score

Analysis of the effectiveness score shows significant associations with prevalence score, and IM leadership: Sole-led. Prevalence score and Sole-led IM are positively correlated with effectiveness score. Effectiveness score is lower for multi-led IM than for sole-led IM. Organization size nor academic affiliation were significantly correlated with prevalence score.

6. Discussion

The exploratory nature of our survey reveals the first attempt that we are aware of, to determine the pervasiveness of emergency management in Canadian healthcare organizations. Furthermore, we are the first study to detail the prevalence of disaster preparedness activities across Canada, and their self-reported effectiveness in response to COVID-19. First, revisiting the descriptive results (Table 2) demonstrate that overwhelmingly, when a preparedness activity was enacted by EM in the period prior to COVID-19 it was reported as effective with a median value of 4.3 out of 5. That suggests that each of the nine activities were perceived as an effective component in preparing health organizations to respond to the pandemic. Next, we discuss the operationalization of the components of disaster preparedness in health organizations.

6.1. Activity interconnectedness

First, we address a lack of understanding on associations between disaster preparedness activities [11]. Simulation, the activity with the lowest prevalence, was shown to enhance the effectiveness of other activities including training for multi-agency response and activating Incident Management, as it was likely these activities were not mutually exclusive. This finding is supported by the work of Skryabina et al., [38]; who found that healthcare staff who took part in simulation were better prepared to respond than those who did not due to improved coordination and confidence with response roles. This inherently makes sense, to conduct effective simulation, training with multi-agency partners is essential, so is live role-play where participants assume incident command roles to understand communication hierarchy and accountability. Further when simulation exercises were reported, such as in academically affiliated or organizations employing a dedicated EM resource, so was the occurrence of almost all other activities, suggesting organizations conducting simulation had a more robust EM program consisting of many activities in unison. Our findings highlight not only the importance of, but also the variation in prevalence of simulation exercises in health organization disaster preparedness.

6.2. IM leadership and training

While training is suggested as a condition for healthcare disaster preparedness, the actual effect of training upon individuals leading emergency responses is relatively unknown [48,49]. We highlight the importance of ensuring those individuals leading IM are trained, this had significant positive difference in both the overall prevalence and effectiveness scores of respondents. Whether IM was led by a single individual or a led by multiple individuals also had a significant bearing upon preparedness activities. The median size of an IM leadership team was one, with 68% of IM leads trained in their roles and the principles of emergency response. While sole-led IM was found to have a significant and positive correlation upon the effectiveness of activities overall, significant increases in the prevalence of key activities, simulation, and table-top scenario planning, were found where multiple individuals led IM. The increase in prevalence of certain activities is likely explained by the fact that the composition of multi-led teams sometimes included an emergency manager as well as other subject matter experts (e.g. infectious disease specialists) who were able to bridge multi-disciplinary teams and access resources necessary to conduct simulations and table-top planning. The multiple led incident command team may have been due to the EOC having a unified command style (ie. Multiple organizational leaders functioning as incident commander concurrently) or a function of a rotational schedule (e.g. A number of individuals taking the role as a singular Incident Commander.) As the literature suggests there is value in unified command structurers for complex situations [50] which seems suitable in a pandemic. Conversely, where one individual leads the emergency response, decisiveness is improved and decisions made more rapidly than where multiple individuals must be consulted. This aligns with other early evidence coming out of the pandemic that shows a sole-physician leader in charge of an IM found the unilateral communication a benefit [43]. We suggest a balance must be found in the leadership of emergency response, acknowledging the importance of multiple views upon important decision making, while still maintaining decisiveness needed for emergency situations. Having adequate support for a sole-led IM is critical, particularly where that individual is not trained in the principles of emergency response. We suggest a dedicated emergency manager can play a supportive coaching role to that individual to enhance preparedness and response.

6.3. Emergency management responsibility

Given the exploratory nature of our study, and with no current statistics on the composition of the health EM workforce in Canada, the emergency management (EM) responsibility indicated by respondents in our survey is a useful approximation for the composition of this workforce. Our findings suggest that individuals with secondary EM responsibility are nearly as prevalent in health organizations as those with a sole and primary responsibility. The dedication of the EM resource influenced the number of preparedness activities enacted. The most drastic difference was the prevalence of simulation exercises, with sole EM more than twice as likely at 40% to have conducted simulation than secondary or emergent EM at 19% each. Sole and primary EM reported higher prevalence in each of the nine activities except for activating a virtual EOC. Interestingly, virtual EOC activation was highly reported by those with emergent responsibility. We suspect this is a direct result of the shift to virtual working environments which became wide-spread during the first wave of the pandemic. Holding for regional variation, our regression shows secondary and emergent EM result in the enactment of less activities overall (approximately 1–1.5 less activities) than sole responsibility EM. We highlight the importance of ensuring each

health organization has a dedicated EM resource who can direct influence upon the number of preparedness activities undertaken, coach IM leaders, and improve overall effectiveness of activities. Moreover, the increased demand for emergency management resources during the pandemic is shown by the emergent EM category. These individuals filled a considerable emergency management void in their respective health organizations. The contribution of those individuals deputized to perform EM duties must not be overlooked when the pandemic ends, so that learning, and capability is not lost when they return to previous roles.

6.4. National health emergency preparedness system

Essential elements of a resilient and prepared national health system are described by Khan et al. [10]; yet the elements contained in that framework are yet to be empirically tested. Our exploratory study helps by describing the pervasiveness of emergency management in the health sector in Canada. Hence our findings contribute to the body of knowledge which supports a Canadian health emergency preparedness system. We present the significant contribution made by the Canadian health sector's emergency management professionals and the disaster preparedness activities they enacted in preparation for COVID-19. We highlight significant regional and organizational variation in the prevalence of activities. The history and legacies of disasters and emergency preparedness in each region of Canada are unique and tell part of the story. While emergencies have increased in frequency, they may still be rare in certain regions of Canada which leads to variability in the commitment of leadership to invest in preparedness [10]. Another element of variation stems from the nature of health systems in each region of Canada [51]. Alberta has a long history of responding to natural disasters including fires and floods which has seen the development of a robust emergency planning and co-ordination capability [52]. Familiarity with activating IM and training for multi-agency response was highest in single system health regions Alberta and Atlantic, while less so in Ontario and British Columbia which are multi-system health regions. Both organization size and academic affiliation saw statistically significant variation in activity prevalence. It was unsurprising that larger organizations tended to have higher prevalence than small, given they tend to have greater resources in proportion with their higher inpatient cases [46]. Academic affiliation was important in terms of driving prevalence of preparedness activities, simulation was more than twice as likely in academic settings. The variation in preparedness activity prevalence of smaller healthcare organizations, for example in rural areas, or not near academic institutions must be given consideration. Both organization size and academic affiliation are important considerations for policy makers of a Canadian health emergency preparedness system to consider. Emergencies and disasters shine a light and public attention upon risks and impacts such as those experienced during the COVID-19 pandemic in Canada. As seen in the last few decades in North America, high profile disasters have led to significant investment in emergency management [10,12,49]. We suspect that COVID-19 will be no different. However, while the field of health emergency preparedness is enhanced by the learning from COVID-19, that learning must be agnostic of COVID-19, so that policy makers directing health system preparedness learn from past mistakes and ensure the important role of emergency management is not overlooked in the recovery.

7. Limitations

This survey reports data provided by respondents working in a health EM capacity during a global pandemic and aims to gather their perceptions on preparedness activity prevalence and effectiveness. The authors recognize the nature of data as self-reported and hence there could possibly be bias in the response to answer questions more positively, as many of the questions are about the work led by, or directly involved health EM Practitioners. While we can speak to the pervasiveness of emergency preparedness among Canadian health organizations we leave unexamined emergency preparedness activities by public health organizations at the provincial and federal level, and non-health organizations (e.g. in natural resources) in the private sector and at the municipal level. As such investigation into these other sectors is necessary to understand the overall picture of the Canadian health emergency preparedness system [10]. In terms of the nine activities we choose for healthcare disaster preparedness, for pragmatic reasons we did not assign a weight to each element, as evidence for this does not exist in the extant literature. As such our results, and future studies in this field, could be improved by the completion of an expert rating on activity effectiveness, to assign weighted value to each activity, as part of overall health emergency preparedness. Further, while we reviewed the evidence and choose our activities in relation to their relevance to COVID-19, we acknowledge that we might have missed preparedness activities which have gone unreported. For example, activities that occurred emergently, conducted outside of the professional domain of emergency management, or which were exclusive to leadership or medical community. As such introducing a qualitative element to understand activity prevalence and effectiveness will improve upon the findings we present in this study.

8. Practical recommendations

Based on our assessment of EM activities we make three explicit recommendations to Canadian health system leaders and policy makers:

- First, uniformity in the training and deployment of emergency managers across Canadian health organizations is necessary. To achieve this, national legislated standards and training programs are required and the Canadian Emergency Management College, equivalent to the USA's Federal Emergency Management Agency (FEMA)'s Emergency Management Institute, which closed in 2012, should be reinstated as a National Emergency Preparedness Centre. This centre must form part of a national healthcare framework for the integration of public health, healthcare delivery, and emergency management in health.
- Second, ensure dedicated EM professionals are employed in each health organization in Canada to help drive the prevalence of key preparedness activities like simulation, training, and to coach organizational leaders who lead the emergency response.
- Third, ensure that smaller health organizations in more rural and isolated areas, such as those without academic affiliation or indigenous communities with heightened risk profiles [10], are not left without adequately skilled and resourced emergency managers, who can ensure facilities are developing disaster preparedness through the enactment of key activities and training.

9. Conclusion

The healthcare system in Canada has been and continues to be under immense strain due to COVID-19. Without the efforts of emergency management professionals bolstering the preparedness of health organization there is no doubt the response to COVID-19 would have been less effective. With variation in the prevalence and effectiveness of disaster preparedness activities by organizational, regional, and leadership characteristics, there are significant challenges ahead for Canadian health policy makers who must take aim at ensuring a more uniform health emergency preparedness system. The learning from COVID-19 must not be lost so that a stronger and more resilient Canadian health emergency preparedness system can be built. Looking to the future, new disasters, such as pandemics, will continue to rise in frequency, duration and complexity, and healthcare systems in Canada and around the world must embrace emergency management principles to ensure they are adequately prepared.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix. Kendall Tau Correlation

Activity Prevalence	Pandemic Planning	Training for multi-agency response	Activating IM	Setting up physical EOC	Setting up virtual EOC	Table-top only scenario planning	Simulation Based Exercises	Donning and doffing PPE training	Clinical management strategies
Pandemic Planning	1								
Training for multi-agency response	0.2541* 0.0019	1							
Activating IM	0.3356* 0	0.2761* 0.0008	1						
Setting up physical EOC	0.2226* 0.0066	0.2548* 0.0019	0.5057* 0	1					
Setting up virtual EOC	0.1191 0.1469	0.1862* 0.0232	0.2659* 0.0012	0.2467* 0.0026	1				
Table-top only scenario planning	0.2009* 0.0143	0.3999* 0	0.2818* 0.0006	0.2712* 0.0009	0.0895 0.2757	1			
Simulation Based Exercises	0.2382* 0.0037	0.3271* 0.0001	0.2953* 0.0003	0.3412* 0	0.2763* 0.0008	0.3208* 0.0001	1		
Donning and doffing PPE training	0.0942 0.2516	0.1934* 0.0183	0.1696* 0.0387	0.1157 0.1585	0.0317 0.7011	0.1398 0.0884	0.1629* 0.0471	1	
Clinical management strategies	0.1269 0.1222	0.2085* 0.011	0.2502* 0.0023	0.1079 0.1884	0.2659* 0.0012	0.0673 0.4129	0.1585 0.0533	0.4349* 0	1

Activity Effectiveness	Pandemic Planning	Training for multi-agency response	Activating ICS	Setting up physical EOC	Setting up virtual EOC	Table-top only scenario planning	Simulation Based Exercises	Donning and doffing PPE training	Clinical management strategies
Pandemic Planning	1								
Training for multi-agency response	0.0945 0.7773	1							
Activating ICS	0.1336 0.6769	0.3536 0.2169	1						
Setting up physical EOC	0.1087 0.7102	−0.2137 0.4316	0.3294 0.2166	1					
Setting up virtual EOC	0.1336 0.6769	0.3536 0.2169	0.1667 0.6033	0.0969 0.7574	1				
Table-top only scenario planning	0.101 0.7463	0.4276 0.1153	0.378 0.1702	0.3076 0.2307	0.5459* 0.0437	1			
Simulation Based Exercises	0.2917 0.2788	0.5831* 0.0261	0.5861* 0.0261	0.2115 0.409	−0.0404 0.9367	0.4736 0.0644	1		
Donning and doffing PPE training	0.1336 0.6769	0.3536 0.2169	0.5833* 0.0376	0.4844 0.0638	0.5833* 0.0376	0.378 0.1702	0.3436 0.2036	1	
Clinical management strategies	0.2893 0.2971	0.2041 0.4781	0.1203 0.7102	0.1846 0.4903	0.5292 0.0511	0 1	0.07 0.8314	0.5292 0.0511	1

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