Challenges in monitoring the development of young children in remote Aboriginal health services

Clinical audit findings and recommendations for improving practice

D'Aprano, A.; Silburn, S.; Johnston, V.; Bailie, R.; Mensah, F.; Oberklaid, F.; Robinson, G.

Published in:
Rural and Remote Health

Published: 01/01/2016

Document Version
Publisher's PDF, also known as Version of record

Rural and Remote Health

MEDLINE listed Impact factor 0.878

ISSN 1445-6354

The International Electronic Journal of Rural and Remote Health Research, Education, Practice and Policy

ORIGINAL RESEARCH

Community emergency department utilization following a natural disaster (the Goderich Tornado)

SD Appavoo[1,2], A Khemlin[2], DM Appavoo[3], CJ Flynn[4]

[1]Schulich School of Medicine and Dentistry University of Western Ontario; Goderich Teaching Site;

[2]Alexandra Marine and General Hospital, Goderich, Ontario, Canada

[3]Ryerson University, Toronto, Ontario, Canada

[4]Gateway Rural Health Research Institute, Seaforth, Ontario, Canada

Submitted: *11 November 2015;* ***Revised:*** *9 May 2016;* ***Accepted:*** *9 June 2016;* ***Published:*** *21 September 2016*

Appavoo SD, Khemlin A, Appavoo DM, Flynn CJ

Community emergency department utilization following a natural disaster (the Goderich Tornado)
Rural and Remote Health **16: 3802. (Online) 2016**

Available: http://www.rrh.org.au

ABSTRACT

Introduction: On 21 August 2011 an F3 tornado hit the Canadian town of Goderich, Ontario, leaving 40 people injured and one dead. Specific medium-term changes in utilization of health care following a disaster have not been analyzed in medical literature. Documenting the emergency department utilization through this subacute period would be helpful to enable institutions and healthcare practitioners to be better prepared for future events.

Methods: A medical chart review was conducted at the Alexandra Marine and General Hospital in Goderich. All emergency department visits made during the 30 days after the Tornado in 2011 (intervention group), 30 days prior to the tornado in 2011 (primary control group), and during the similar calendar period of 30 days after the tornado in 2010 (seasonal control group) were reviewed. Medical diagnoses of all patients who presented at the emergency department were collected and compared.

Results: Fewer people presented to the emergency department following the tornado than during the control periods, and those who did were significantly older than those who presented in the control periods ($p<0.001$). A significantly greater number of patients presented with undiagnosed medical problems, many came to refill their medications, and significantly fewer people left the emergency department without being seen ($p<0.001$).

Conclusions: This study identifies the medical conditions that are most likely to be seen in an emergency department following a tornado in a rural Ontario community. This information serves to inform the medical community and other hospitals how to increase their level of preparedness should a comparable disaster occur again in the future.

Key words: Canada, community emergency department, disaster, emergency department utilization, rural community hospital, tornado.

Introduction

Tornadoes are severe wind storms that produce forceful rotating winds and form funnel-shaped vortexes[1]. In Canada, the peak of the tornado season is between June and August[2]. Predominantly, Canadian tornadoes have maximum wind speeds of less than 180 km/h, but a small number of them can be substantially stronger and have devastating impact wherever they touch down[2].

Goderich, a town located in Huron County in the Canadian province of Ontario, is located on the eastern shore of Lake Huron. At the time of the tornado, the town had 7521 inhabitants[3]. A powerful and violent F3 tornado passed through Goderich around 4.00 pm on Sunday, 21 August 2011[4]. Wind speeds reached between 250 and 300 km/h[4]. At its widest, over downtown, the tornado was estimated to be 1.5 km across, and its path was an estimated 20 km long[4]. The tornado caused devastating damage to the town's port and historic downtown center, as well as to several blocks of residential homes. Forty people were injured and one person was killed by Ontario's strongest tornado since 1996[4,5].

The immediate and delayed harmful effects of tornadoes on the physical and mental health of those affected during the event have been well documented in literature (Tables 1,2)[1,6-18].

Freedy and Simpson estimated that the use of primary healthcare services typically increases for 12 or more months following a major disaster[7]. However, the acute and subacute impacts of tornadoes in the medium-term, as in the 30-day period on a community hospital's emergency department (ED), close to the tornado strike zone, have not been investigated, to date. During this time period following a disaster, outside sources of help might be unavailable or unreliable[6], particularly in a rural area, so the availability and functioning of the local ED is crucial to a community's wellbeing. It would be expected that the nature and quantity of ED visits during the 30 days following a tornado may be altered as compared to a similar 30-day period not following a natural disaster. Approximately 80 tornadoes are reported in Canada each year, and Southern Ontario is considered a high-risk zone[19], so it is very possible that a disaster like this could affect another community in this region in the future. Given the impact of tornadoes, an understanding of ED resource requirements to respond to such disasters in the medium term, as well as the short- and long-term, is paramount. Obtaining a greater understanding of what resources are required following these events could better prepare both healthcare and emergency relief teams to provide better access to the services that are most needed.

In this study, the utilization of the ED services of the Alexandra Marine and General Hospital (AMGH) in Goderich, the closest hospital to the Goderich Tornado area, was measured to determine the urgent medical needs of a rural Southwestern Ontario community, affected by a tornado, during the 30 days following the disaster.

Informal interviews with physicians, who worked in the AMGH ED during the 30-day period after the tornado, generated the following hypotheses for the research. In the 30-day period following the tornado, medical conditions presented to the ED would differ from usual presentations at that time of year, reflecting the types of injury expected to be a consequence of the hazards presented by the tornado event and the related disruption of community services. For example, increased rates of soft tissue injuries, laceration and contaminated wounds, bee stings, fractures, acute stress reaction, alcohol abuse, anxiety, depression, and failure to cope at home were expected. Also anticipated was the need for follow-up care and requests to refill medications lost or destroyed during the tornado, particularly for the reason that physicians' practices in the community were inaccessible after the tornado.

Methods

A retrospective medical chart review of all the patients who presented to the AMGH emergency department in the first 30 days following the tornado, between 21 August 2011 and 20 September 2011 (known as the After Tornado

2011 group), was conducted. Data, including age and gender (demographic variables) and diagnoses (dependent variables), were collected on all patients who visited the ED during the study timeframe. In addition, two control groups were established: Before Tornado 2011 and Seasonal 2010. The Before Tornado 2011 group data included medical diagnoses and demographic data of all patients who presented to the ED in the 30 days prior to the event, between 22 July and 21 August 2011 (primary control group). The Seasonal 2010 group data were for all patient encounters made in the corresponding time period in the previous year, between 21 August 2010 and 20 September 2010, to establish whether the changes that occurred after the tornado were in any way related to the time of year in which the tornado had occurred, rather than to the event itself.

The *International Classification of Diseases*, *10th Revision* (ICD-10) was used to code the diagnoses to standardize the data[20]. ICD-10 coding system breaks down patients' diagnoses into 26 categories (based on similar diagnoses amongst the categories) that are designated by a letter of the alphabet (A-Z)[20]. ICD-10 diagnostic criteria comparisons did not include the diagnoses of those patients who left the ED without being seen (their diagnoses were not available).

Statistical analysis

A χ^2 test, assuming that equal proportions were expected during each period, was used to compare the total number of patients who visited the ED in each of the three time periods. A one-way analysis of variance (ANOVA) test was used for among-group age comparisons. A Dunnett's *t*-test[21] was used to compare the two control time periods against the 30-day period following the tornado. For gender, a χ^2 test was used to make among-group comparisons. Among-group comparisons of individual alphabetic ICD-10 categories were made using either a χ^2 test or, where applicable, a Fisher's exact test[22]. When the overall ICD-10 alphabetic categories comparisons were statistically significant, the After Tornado 2011 group was compared with each of the Before Tornado 2011 and Seasonal 2010 groups with a Bonferroni correction. ICD-10 categories, in which difference in the frequency of diagnoses showed significance, were further subdivided to identify particular diagnoses or groups of diagnoses that were responsible for this significance. Among-group comparisons of subcategories were made using either χ^2 test or, where applicable, Fisher's exact test with a Bonferroni correction for making pairwise comparisons.

All statistical analyses were conducted using Statistical Analysis System software v9.3 (SAS Institute, v9.3; http://www.sas.com). Hypothesis tests were conducted using a two-tailed level of significance, and results were declared significant at the 5% critical level ($p<0.05$).

Ethics approval

Ethics approval was obtained from the Health Sciences Research Ethics Board of the University of Western Ontario (#18699E).

Results

The number and demographic characteristics of patients presenting in each of the three time periods are presented in Table 3. The number of patients visiting the ED differed across the time periods ($p<0.001$). Significantly fewer patients visited the ED after the tornado (After Tornado 2011 group) than presented to the ED before the tornado in 2011 (Before Tornado 2011 group – primary control group), and in the same calendar period in 2010 (2010 Seasonal control group). Regarding demographic characteristics, there were differences across the three time periods in terms of age ($p<0.001$), with patients visiting the ED following the tornado being significantly older than those in the two control groups. Although there were proportionally more males presenting following the tornado in 2011, the difference was not significant ($p=0.264$).

The ICD-10 categorical diagnoses of patients who presented to the ED between 21 August and 20 September 2011 and involved in the primary and seasonal control groups are presented in Table 4.

Table 1: Common post-disaster physical health problems[6]

Acute injuries	Acute problems (present in one-month period after a disaster)	Chronic problems (present after a 12-month period following a disaster)	Medically unexplained physical symptoms
Cuts or abrasions Fractures Motor vehicle crashes Occasional self-inflicted wounds Sprains or strains	Gastroenteritis or dehydration Head lice Pulmonary problems Rashes Rodent-borne illness Self-limited viral symptoms Toxic exposure Vector-borne illness	Congestive heart failure Diabetes Hypertension Pulmonary problems (chronic obstructive pulmonary disease, asthma, acute bronchitis)	Fatigue Gastrointestinal complaints Headaches Other generally vague somatic complaints without clear organic etiology

Table 2: Common post-disaster mental health problems[6]

Acute responses	Chronic problems	New-onset mental health problems
Cognitive dysfunction or distortion Dysfunctional interpersonal behaviors Emotional lability Non-organic physical symptoms	Alcohol abuse or dependence Depression Interpersonal violence Post-traumatic stress disorder or other anxiety disorders Schizophrenia or other severe chronic disorders	Acute stress disorder possibly evolving to post-traumatic stress disorder Alcohol abuse or dependence Depression Interpersonal violence

Table 3: Comparison of demographics and numbers of Alexandra Marine and General Hospital emergency department visits across three time periods

Characteristic	After Tornado 2011 (n(%))	Before Tornado 2011 (n(%))	Seasonal Tornado 2010 (n(%))	p-value
Emergency department visits (total)	1310 (30.4%)	1616 (37.5%)	1384 (32.1%)	<0.001*
Age – mean (standard deviation)	48.0 (25.1)	43.8 (25.8)	45.8 (25.5)	<0.001*
Sex – female	660 (50.4%)	824 (51.0%)	738 (53.3%)	0.264

* Significant at $p<0.05$

Based on the study's grouped ICD-10 coding system, five diagnostic categories were identified as significant across all three study time periods. They were A-B, H, R, W-X, and Y-Z. ICD-10 categories that were found to be statistically significant were further subdivided to particular diagnoses or groups of diagnoses as shown in in Tables 5 to 10.

ICD-10 category A-B included all cases of bacterial, viral, fungal, and parasitic infections. This category was further subdivided. After the tornado, it was noted that the percentage of patients diagnosed with sexually transmitted infections was proportionally greater than that of both control groups, and the percentage of skin infections was proportionally lower. However, there was no evidence that the proportions reported with these particular diagnoses significantly differed across the three time periods (p=0.450, Table 5).

Rural-and-Remote-Health
The International Electronic Journal of Rural and Remote Health Research, Education Practice and Policy

Table 4: Comparison of ICD-10 category diagnoses among three time periods

ICD-10 category diagnosis	After Tornado 2011 (*n*=1310) (*n*(%))	Before Tornado 2011 (*n*=1616) (*n*(%))	Seasonal 2010 (*n*=1384) (*n*(%))	*p*-value
A and B: Infectious/parasitic diseases	29 (2.2%)	69 (4.3%)*	56 (4.1%)*	0.005*
C or D: Malignant, neoplasm/blood and blood forming organ diseases	8 (0.6%)	12 (0.8%)	8 (0.6%)	0.824
E: Endocrine/metabolic diseases	12 (0.9%)	15 (0.9%)	14 (1.0%)	0.958
F: Mental and behavioral disorders	43 (3.3%)	44 (2.8%)	38 (2.8%)	0.655
G: Diseases of the nervous system	16 (1.2%)	23 (1.5%)	32 (2.3%)	0.055
H: Diseases of eye and ear	68 (5.2%)	155 (9.8%)*	96 (7.0%)	<0.001*
I: Diseases of the circulatory system	29 (2.2%)	50 (3.1%)	42 (3.1%)	0.267
J: Diseases of the respiratory system	135 (10.3%)	185 (11.6%)	142 (10.4%)	0.420
K: Diseases of the digestive system	56 (4.3%)	95 (6.0%)	80 (5.8%)	0.093
L: Diseases of the skin and subcutaneous tissue	77 (5.9%)	88 (5.5%)	104 (7.6%)	0.054
M: Diseases of the musculoskeletal system and connective tissue	69 (5.3%)	82 (5.2%)	92 (6.7%)	0.139
N: Diseases of the genitourinary system	95 (7.3%)	92 (5.8%)	87 (6.4%)	0.272
O: Diseases of pregnancy, childbirth	4 (0.3%)	11 (0.7%)	6 (0.4%)	0.315
P: Conditions originating in the perinatal period	0 (0.0%)	0 (0.0%)	0 (0.0%)	–
Q: Congenital malformations, and chromosomal abnormalities	0 (0.0%)	0 (0.0%)	2 (0.2%)	0.197
R: Symptoms, are not elsewhere classified	144 (11.0%)	131 (8.2%)*	152 (11.1%)	0.013*
S-V: Injury, poisonings, external causes (burns/accidents)	253 (19.3%)	311 (19.6%)	253 (18.5%)	0.737
W-X: External causes (insect/animal bites/falls)	53 (4.1%)	41 (2.6%)	21 (1.5%)*	<0.001*
Y-Z: Factors influencing health status and contact with health services	218 (16.7%)	186 (11.7%)*	145 (10.6%)*	<0.001*
Left emergency department without being seen	1 (0.1%)	26 (1.6%)*	14 (1.0%)*	<0.001*

* Significant at $p<0.05$
ICD-10, *International Classification of Disease, revision 10*

Table 5: Distribution of diagnoses ICD-10 categories A-B among the three time periods

ICD-10 diagnosis A-B	After Tornado 2011 (n=29) (n(%))	Before Tornado 2011 (n=69) (n(%))	Seasonal 2010 (n=56) (n(%))	p-value
Systemic infections	14 (48.3%)	40 (58.0%)	26 (46.4%)	
Skin infections	6 (20.7%)	17 (24.6%)	15 (26.8%)	
Fungal infections	5 (17.2%)	10 (14.5%)	9 (16.1%)	
Sexually Transmitted Infections	4 (13.8%)	2 (2.9%)	6 (10.7%)	0.450

Table 6: Distribution of diagnoses ICD-10 categories H among the three time periods

ICD-10 diagnosis H	After Tornado 2011 (n=68) (n(%))	Before Tornado 2011 (n=155) (n(%))	Seasonal 2010 (n=96) (n(%))	p-value
Eye trauma	2 (2.9%)	14 (9.0%)	12 (12.5%)	
Other eye problems	17 (25.0%)	32 (20.7%)	21 (21.9%)	
Ear infection	43 (63.2%)	104 (67.1%)	58 (60.4%)	
Other ear problems	6 (8.8%)	5 (3.2%)	5 (5.2%)	0.241

Category H included all cases of ear and eye complaints. Significantly fewer of these cases presented to the ED after the tornado in 2011 than in both the primary and seasonal control periods. This category is further subdivided in Table 6 to determine if there was a difference in the proportions of any particular diagnoses within this category. Relatively fewer trauma-related eye complaints, more non-trauma related eye complaints, and more non-infection related ear diseases were identified after the tornado than in both the primary and the seasonal control periods. However, the difference in proportions of cases reporting with ICD-10 category H was not statistically significant across the three time periods (p=0.241).

Category R included symptoms, signs, abnormal results of clinical or other investigative procedures, and ill-defined conditions for which classifiable diagnoses were not recorded elsewhere. Practically all diagnoses in category R could be designated as 'not otherwise specified', 'unknown etiology', or 'transient'. Breakdown of the R category revealed that the proportions of cases reported with the same category differed across the three time periods (p=0.030, Table 7). Although these proportions did not differ significantly between the After Tornado 2011 and the Before Tornado 2011 groups they did differ significantly between the After Tornado 2011 and Seasonal 2010 groups, with a greater proportion of cases of undiagnosed general and medical conditions related to circulatory and respiratory systems being observed in the After Tornado 2011 group.

Categories W and X contained all cases of accidental injury by external causes, including insect and animal bites, falls and other injuries. The proportions of particular diagnoses, which were consistent with category W and X, differed significantly across the three time periods (p=0.009, Table 8). Although the proportions did not differ significantly between the After Tornado 2011 and the Before Tornado 2011 groups, there were significantly higher proportions of insect and animal bites in the After Tornado 2011 group than in the Seasonal 2010 group. Conversely, greater proportions of other injuries (particularly falls) were identified in the Seasonal 2010 group than in the two groups in 2011.

Table 7: Distribution of diagnoses ICD-10 categories R among the three time periods

ICD-10 diagnosis R	After Tornado 2011 (*n*=144) (*n*(%))	Before Tornado 2011 (*n*=131) (*n*(%))	Seasonal 2010 (*n*=152) (*n*(%))	*p*-value
Undiagnosed general conditions	47 (32.6%)	31 (23.7%)	33 (21.7%)	
Undiagnosed circulatory/respiratory problems	40 (27.8%)	35 (26.7%)	31 (20.4%)	
Other undiagnosed medical problems	57 (39.6%)	65 (49.6%)	88 (57.9%)	0.030*

* Significant at $p<0.05$

Table 8: Distribution of diagnoses ICD-10 categories W-X among the three time periods

ICD-10 diagnosis W-X	After Tornado 2011 (*n*=53) (*n*(%))	Before Tornado 2011 (*n*=41) (*n*(%))	Seasonal 2010 (*n*=21) (*n*(%))	*p*-value
Bee stings/insect bites	36 (67.9%)	29 (70.7%)	14 (66.7%)	
Animal bites	10 (18.9%)	10 (24.4%)	0 (0.0%)	
Falls and other injuries	7 (13.2%)	2 (4.9%)	7 (33.3%)	0.009*

* Significant at $p<0.05$

Table 9: Distribution of diagnoses ICD-10 categories Y-Z among the three time periods

ICD10 Diagnosis Y-Z	After Tornado 2011 (*n*=218) (*n*(%))	Before Tornado 2011 (*n*=186) (*n*(%))	Seasonal 2010 (*n*=145) (*n*(%))	*p*-value
Medications	82 (37.6%)	58 (31.2%)	19 (13.1%)	
Follow-ups	97 (44.5%)	91 (48.9%)	103 (71.0%)	
Tests	13 (6.0%)	8 (4.3%)	13 (9.0%)	<0.001*
Procedures	23 (10.6%)	23 (12.4%)	7 (4.8%)	
Other	3 (1.4%)	6 (3.2%)	3 (2.1%)	

* Significant at $p<0.05$

Table 10: Patient who left the ED without being seen by a healthcare professional

Patient status	After Tornado 2011 (*n*=1310) (*n*(%))	Before Tornado 2011 (*n*=1616) (*n*(%))	Seasonal 2010 (*n*=1384) (*n*(%))	*p*-value
Left emergency department without being seen	1 (0.1%)	26 (1.6%)	14 (1.0%)	<0.001*

* Significant at $p<0.05$

Category Y and Z included all visits primarily seeking various health services, including medication administration, laboratory tests, and follow-up visits. These services are further subdivided in Table 9. Overall there was a difference in the proportions across the three time periods ($p<0.001$). The proportions of particular services included in Category Y and Z did not differ significantly between the After Tornado 2011 and the Before Tornado 2011 groups. However, there were significantly greater proportions of patients who requested prescription refills, medication administration, or needed medical procedures in the After Tornado 2011 group than in the Seasonal 2010 group.

Finally, it should be noted that only one patient left the ED without being seen by a healthcare professional following the tornado in 2011. This number was less than what was observed in both the primary and seasonal control periods (p<0.001, Table 10).

Discussion

Overall, the study findings were unexpected and are, therefore, an important addition to the current literature. According to previous literature reports, the hospitals closest to a disaster area are often compromised because of structural damage and are easily overwhelmed by accepting a large number of victims[19]. Fortunately, the AMGH was north of the tornado's trajectory in Goderich and sustained limited damage. In addition, the hospital's generator allowed the AMGH to continue functioning during the 32-hour electrical shortage experienced in the surrounding region. Considering the magnitude of the destruction in Goderich, it is remarkable that the tornado resulted in only one death and did not result in a significant increase in the presentation of trauma or infectious illness in the days following the event. In fact, the total volume of patients that presented to the ED following the tornado was significantly lower than what would be expected for that time of year. A related finding was that only one individual who presented to the ED left without being seen, and this number was unmatched in both our study's primary and seasonal control periods. This suggests that the patients may have actually received more efficient and timely treatment following the tornado.

There are multiple possible explanations for the reduced number of patients presenting to the ED. First, there are four other hospitals within 50 km of Goderich, the nearest of which is only 20 km away, in Clinton, Ontario. It is possible that less critical patients decided to attend one of these neighboring facilities in order to reduce the burden on their own hospital. Indeed, as a consequence of road closures and debris left in the wake of the tornado, those living in the south end of town may actually have found it easier to travel to another community than to navigate through the debris left in the wake of the tornado to get to the north end of Goderich, where the AMGH is located. These obstructions lasted for several weeks after the disaster. Second, it is possible that the decrease in the number of tourists in Goderich after the tornado played a role in fewer visits to the ED. Tourists, who generally flood the Goderich area during the summer, could not get to the town because of the blocked roads. The Goderich Tourism Information Center received 10 350 calls and visits in 2011. This number was significantly lower than the 13 582 calls and visits it received in 2010 (23.8% reduction)[4]. Third, it is also possible that those who were not critically ill decided not to seek any treatment. Last, it might be that the Goderich Tornado did not cause a significant impact on the residents' health, or significantly change the demand for medical care in the community. These four hypotheses cannot be confirmed without determining the changes in patient volume and reasons for presenting to the ED observed in neighboring hospitals in the area during the study timeframe.

Only one individual who presented to the emergency department left without being seen. This is consistent with other research on ED use indicating that delay in assessment is the most common reason for patients to leave an ED without being seen[23]. In the timeframe of the study, the total number of patients presenting was significantly less than for primary and seasonal control periods, and the department's staffing was enhanced as per AMGH emergency department disaster protocols. This may have resulted in shorter wait times, and hence fewer patients left without being seen. It is also possible that those patients who did visit the ED following the tornado were more urgently in need of treatment than the patients in the control groups and therefore less likely to leave. This conclusion is further supported by the finding that the age of patients presenting to the hospital after the tornado was significantly greater than the age of those presenting prior to the storm. It has been previously identified that both minor and severe morbidity rates following a tornado increase with age, and this result is independent of the propensity for elderly patients to seek medical attention[9]. This is believed to be due to the greater susceptibility of elderly people to trauma, decreased mobility, and increased number of co-morbid conditions[9]. Thus, it is likely that the cohort presenting after the tornado was older because it represented those most in need.

Carter et al. reported that gastroenteritis, self-limited viral syndrome, and vector-borne illness are common post-disaster health problems[8]. Interestingly in this case, there was no significant increase in these medical conditions. This situation is likely explained by the fact that despite the significant destruction caused to the town's electrical utility and infrastructure, no problems were reported with the tap water supply or sewer system[4]. Access to clean water and sanitation is crucial for prevention of water contamination and thus water-borne and other communicable infectious diseases[24].

Similarly, eye- and ear-related concerns and infectious and parasitic diseases all significantly decreased following the tornado compared to the control periods. However, this significance was not apparent when broken down into infectious and parasitic illnesses and ear and eye diseases. Based on the research data, the Goderich Tornado did not result in a significant infectious disease outbreak, traumatic and non-traumatic eye or ear problems for the affected population.

Injuries were hypothesized to be the category with the greatest significant increase in emergency visits following the tornado. Although injured people did present to the ED after the storm, in greater numbers than prior to the tornado, it was not higher than what would be expected for that time of year as suggested by the seasonal control. This result may be explained by the fact that injuries are known to be more prevalent during the summer months than at other times of the year[13,25-30]. Thus, it is possible that this increase was in keeping with the normal volume of injuries during the time of year in which the tornado occurred.

Cases presenting to the ED involving external causes of injuries, including insect and animal bites, were not significantly greater following the tornado. Statistical analysis showed no difference in those medical problems between the After Tornado 2011 group and the Before Tornado 2011 group; however, in the After Tornado 2011 group there were a significantly higher proportion of insect and animal bites than in the Seasonal 2010 group. This result differs from those reported in previous literature, which suggested that the displacement of domesticated animals, rats, insects, snakes, and reptiles following a natural disaster often results in an increased incidence in bites[31-33]. In particular, animal bites are largely due to volunteers helping to return displaced animals to their homes. Indeed, it is likely that this displacement also accounts for the increased number of insect bites that occur following a tornado. Based on previous literature, almost half of all the volunteers on clean-up crews following a disaster in the USA are afflicted by insect bites[34]. Given the extreme damage done to the town's flora, the season in which the tornado occurred, and the great number of individuals who volunteered to assist with the clean-up efforts, it is difficult to explain the lower-than-expected number of citizens who experienced insect and animal bites in the period following the storm. Once again, it is likely that the ED only witnessed the most extreme reactions to these bites.

The present research revealed a significant increase in the category of undiagnosed general conditions and the category of circulatory and respiratory system conditions compared with the Seasonal 2010 group. These findings coincide with previously reported observations that medically unexplained physical symptoms are common following a disaster[7]. These unexplained or undiagnosed symptoms are also associated with mental health problems (such as depression, post-traumatic stress disorder, and other anxiety disorders) or with somatic complaints without organic cause[7].

Significantly more patients visited the ED following the tornado for various health services normally provided in a family practice setting, particularly for medication requests. This was expected as it has been previously reported that people who seek relief at shelters following a disaster because of the severe damage inflicted on their homes often do not bring their medications with them[7,14]. Furthermore, when prescriptions are retained in such circumstances, it is possible that the local pharmacy's supplies are insufficient to fulfill the population's increased demands following a destructive storm[27]. Thus, healthcare facilities, as well as pharmacies, should anticipate this increased need for medications following a disaster and make the appropriate adjustments to address this need as much as possible.

Conclusions

The type of medium-term demands on an ED following a severe weather event will vary depending on predominant health issues in the area prior to the event, the type of injuries subsequent to the event, and the impact of the event on community infrastructure and resources. In this case, when other primary healthcare delivery systems were disrupted in a small community, an intact ED was called upon to provide and coordinate a wider range of healthcare services than they normally would.

Acknowledgements

The authors would like to acknowledge the contributions of Connie McMillan, Nancy Larabee, Heather Skirten, Wendy MacKenzie, Joanne McCallum, Mary Schreinert, Jennifer Beaudry, Alana Ross, and Alice Koopmans to the study's data collection. The authors would like to thank the Gateway Rural Health Research Institute for support and assistance with conducting the study.

References

1. Ablah E, Tinius A, Konda K, Synovitz C, Subbarao I. Regional health system response to the 2007 Greensburg, Kanzas, EF5 Tornado. *Disaster Medicine and Public Health Preparedness* 2007; **1:** 90-95. http://dx.doi.org/10.1097/DMP.0b013e31815901dc

2. Environment Canada. *Tornado – nature's dangerous wonder.* (Internet) 2015. Available: http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=6C5D4990-1#tornadoes (Accessed 5 October 2015).

3. Ontario Ministry of Agriculture and Food. *Huron County at a glance.* (Internet) 2011. Available: http://www.omafra.gov.on.ca/English/stats/county/index.html (Accessed 5 December 2011).

4. Rotteau L. *Goderich Tornado report for emergency services organizations*. 2011. Goderich, ON: Town of Goderich, 2011.

5. Environment Canada. *Canada's top ten weather stories for 2011*. (Internet) 2015. Available: http://www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=3A880EEA-1 (Accessed 5 October 2015).

6. May AK, McGwin G Jr, Lancaster LJ, Hardin W, Taylor AJ, Holden S, et al. *The April 8, 1998 tornado: assessment of the trauma system response and the resulting injuries. Journal of Trauma* 2000; **48(4):** 666-672. http://dx.doi.org/10.1097/00005373-200004000-00014

7. Freedy J, Simpson W. Disaster-related physical and mental health: a role for the family physician. *American Family* Physician 2007; **75:** 841-846.

8. Carter AO, Millson ME, Allen DE. Epidemiologic study of deaths and injuries due to tornadoes. *American Journal of Epidemiology* 1989; **130(6):** 1209-1218.

9. Seaman J. *Epidemiology of natural disasters*. New York: Karger, 1984.

10. Daley WR, Brown S, Archer P, Kruger E, Jordan F, Batts D, et al. Risk of tornado-related death and injury in Oklahoma, May 3, 1999. *American Journal of Epidemiology* 2005; **161(12):** 1144-1150. http://dx.doi.org/10.1093/aje/kwi142

11. Morris B, Armstrong TM. Medical response to a natural disaster: the Barrie tornado. *Canadian Medical Association* Journal 1986; **134:** 767-769.

12. Glass R, Craven B, Bregman D, Stoll B, Horowitz N, Kerndt P, Winkle J. Injuries from the Wichita Falls tornado: implications for prevention. *Science* 1980; **207:** 734-738. http://dx.doi.org/10.1126/science.207.4432.734

13. Mandelbaum I, Nahrwold D, Boyer DW. Management of tornado casualties. *Journal of Trauma* 1966; **6:** 353-361. http://dx.doi.org/10.1097/00005373-196605000-00005

14. Miller A, Arquilla B. Chronic diseases and natural hazards: impact of disasters on diabetic, renal, and cardiac patients. *Prehospital Disaster Medicine* 2008; **23(2):** 185-194. http://dx.doi.org/10.1017/S1049023X00005835

15. Richard J. Rehabilitation of victims of natural disasters. *Journal of* Rehabilitation 1996; **62(4):** 28.

16. Satcher D, Friel S, Bell R. Natural and manmade disaster and mental health. *JAMA* 2007; **298:** 2540-2542. http://dx.doi.org/10.1001/jama.298.21.2540

17. Raphael B, Ma H. Mass catastrophe and disaster psychiatry. *Molecular Psychiatry* 2011; **16(3):** 247-251. http://dx.doi.org/10.1038/mp.2010.68

18. Krug EG, Kresnow M, Peddicord JP, Dahlberg LL, Powell KE, Crosby AE, et al. Suicide after natural disasters. *New England Journal of Medicine* 1998; **338(6):** 373-378. http://dx.doi.org/10.1056/NEJM199802053380607

19. Weir E. Tornadoes and disaster management. *Canadian Medical Association Journal* 2000; **163(6):** 756.

20. World Health Organization. *International statistical classification of diseases and related health problems-(ICD), 10th revision.* (Internet) 2013. Available: http://www.who.int/classifications/icd/en/ (Accessed 24 July 2013).

21. Dunnett C. A multiple comparison procedure for comparing several treatments with a control. *Journal of the American Statistical Association* 1955; **50(272):** 1096-1121. http://dx.doi.org/10.1080/01621459.1955.10501294

22. Fisher RA. On the interpretation of $\chi 2$ from contingency tables, and the calculation of P. *Journal of the Royal Statistical Society* 1992; **85(1):** 87-94. http://dx.doi.org/10.2307/2340521

23. Hsia R, Asch S, Weiss R, Zingmond D, Liang L, Han W, et al. Hospital determinants of emergency department left without being seen rates. *Annals of Emergency Medicine* 2011; **58(1):** 24-32. http://dx.doi.org/10.1016/j.annemergmed.2011.01.009

24. Lechat MF. Disaster epidemiology. *International Journal of Epidemiology* 1975; **4(1):** 5-7. http://dx.doi.org/10.1093/ije/ 4.1.5

25. Greenough G, McGeehin M, Bernard SM, Trtanj J, Riad J, Engelberg D. The potential impacts of climate variability and change on health impacts of extreme weather events in the United States. *Environmental Health Perspectives* 2001; **109(Suppl 2):** 191-198. http://dx.doi.org/10.2307/3435009

26. Fayard GM. Fatal work injuries involving natural disasters, 1992-2006. *Disaster Medicine and Public Health Preparedness* 2009; **3(4)**: 201-209. http://dx.doi.org/10.1097/DMP.0b013e3181b 65895

27. Jhung MA, Shehab N, Rohr-Allegrini C, Pollock DA, Sanchez R, Guerra F, et al. Chronic disease and disasters. Medication demands of Hurricane Katrina evacuees. *American Journal of Preventive Medicine* 2007; **33(3):** 207-210. http://dx.doi.org/10.1016/j.amepre.2007.04.030

28. Singer AJ, Thode HC Jr, Hollander JE. National trends in ED lacerations between 1992 and 2002. *American Journal of Emergency Medicine* 2006; **24(2):** 183-188. http://dx.doi.org/10.1016/j.ajem.2005.08.021

29. Little DC, Vermillion JM, Dikis EJ, Little RJ, Custer MD, Cooney DR. Life on the farm – children at risk. *Journal of Pediatric Surgery* 2003; **38(5):** 804-807. http://dx.doi.org/10.1016/jpsu.2003.50171

30. Mo F, Turner MC, Krewski D, Merrick J. Adolescent injuries in Canada: findings from the Canadian community health survey, 2000–2001. *International Journal of Injury Control and Safety Promotion* 2006; **13(4):** 235-244. http://dx.doi.org/10.1080/17457300600935122

31. Ussher J. Philippine flood disaster. *Journal of the Royal Navy Medical Service* 1973; **59(2):** 81-83.

32. Centers for Disease Control and Prevention. Morbidity and mortality associated with Hurricane Floyd – Northan Carolina, September–October 1999. *Morbidity and Mortality Weekly Report* 2000; **49(17):** 369.

33. Du W, FitzGerald GJ, Clark M, Hou XY. Health impacts of floods. *Prehospital Disaster Medicine* 2010; **25(3):** 265-272. http://dx.doi.org/10.1017/S1049023X00008141

34. Swygard H, Stafford RE. Effects on health of volunteers deployed during a disaster. *American Surgery* 2009; **75(9):** 747-752.

