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Enhancing Health Care Worker Ability to Detect and Care for Patients with Monkeypox, Democratic Republic of the Congo

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Abstract

Background—Monkeypox (MPX) is an endemic disease of public health importance in the Democratic Republic of the Congo (DRC). In 2010, the DRC Ministry of Health joined with external partners to improve MPX surveillance in the Tshuapa Health District of DRC. A pivotal component of the program is training of health zone personnel in surveillance methods and patient care. In this report we evaluate outcomes of the training program.

Methods—Health care worker knowledge of key concepts in the MPX training curriculum was assessed using an anonymous self-administered survey. Additionally, evaluators collected feedback about the capacity of participants to perform the surveillance tasks. Training impacts were determined by assessing various surveillance performance metrics.

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<u>Authors' Contributions</u>

MGR and AMM conceived the study; JB and DMT designed the study protocol; RLS, MB, JK, BN and JM carried out the training exercises and explained evaluation procedures to the participants; EP and SK performed laboratory testing on the clinical specimens and analyzed and interpreted the findings. BN, EP, RS, JM, AMM, BPM, JB, DMT and IKD trained health care workers in specimen collection, and surveillance procedures. JB and MGR drafted the manuscript; EO, IKD and AMM critically revised the manuscript for intellectual content. MGR is the guarantor of this paper. All authors read and approved the final manuscript.

Results—Correct trainee responses to questions about MPX symptoms and patient care increased significantly upon completion of training events. During the 12 months after the initial training, the proportion of suspected cases investigated increased significantly (from 6.7 to 37.3%), as compared to the 5 months prior. However, the proportion of reported cases that were ultimately confirmed remained unchanged, 20.1% (5/24) vs. 23.3% (60/257).

Conclusions—We have demonstrated that the MPX curriculum developed for this initiative was effective in transferring knowledge and was associated with improved detection of human MPX cases.

Keywords

Monkeypox; zoonosis; training evaluation; surveillance; PCR

Introduction

The World Health Organization-Africa Region's (WHO-AFRO) Integrated Disease Surveillance and Response (IDSR) program outlines several principles as being critical for the establishment and maintenance of surveillance systems that are responsive to emerging public health threats. Among these is the need to ensure that health officers and staff have the appropriate knowledge and skills to perform their assigned surveillance and response tasks.[1] While some surveillance tasks may be specific to a particular disease (e.g. collection of sputum specimens for tuberculosis), the core elements of IDSR—detection, notification, confirmation, reporting etc. – are applicable across a broad array of diseases.[2] The 19 communicable diseases prioritized by WHO-AFRO for IDSR implementation include major endemic diseases of public health importance, diseases targeted for eradication or elimination and epidemic-prone diseases.[3] Although not a focus of broad regional IDSR programs, monkeypox (MPX) is a major endemic disease of public health importance in the Democratic Republic of the Congo (DRC), and was made nationally notifiable in 2000. Consistent with principles outlined for IDSR programs, task-oriented instruction in the practice of surveillance through in-service training is fundamental to monkeypox surveillance activities in DRC. Understanding training needs and training outcomes is the focus of this report.

Monkeypox virus (MPXV) is a zoonotic virus found in the rain forest regions of Central and West Africa. In humans, infection with MPXV results in a febrile rash illness resembling discrete, ordinary smallpox. Humans contract MPX through direct contact with infected wildlife or other humans.[4–7] The virus was first discovered in laboratory non-human primates in 1958, but human disease was not identified until 1970 during smallpox eradication efforts in the DRC. From 1981 to 1986, the World Health Organization (WHO) sponsored a surveillance initiative to assess the clinical and public health significance of MPX. These data revealed a case fatality rate of more than 10%, but an inter-human transmission rate insufficient to pose a serious epidemic, as such formal surveillance ceased.[8–10] Reports of increased MPX cases led to several investigations from 1996–1998 which, although complicated by civil unrest and concurrent varicella outbreaks, suggested a greater inter-human transmissibility than previously demonstrated and raised concern that waning immunity after cessation of smallpox vaccination was driving increased incidence.[11,12] Investigations completed during the last decade have further emphasized the problem of disease re-emergence.[13,14]

Currently in DRC, oversight for surveillance response activities is provided by the National Program for Monkeypox and Hemorrhagic Fevers. Guidelines call for biweekly notification and reporting of disease incidence with concomitant investigation of all suspect cases. Case investigations include collection and submission of a diagnostic specimen and case report form (the latter necessitating patient or family interview). However, there are many challenges to successful case detection and subsequent investigation. Most MPX cases occur in remote regions with poor transportation and communication infrastructure, where medical and public health personal have many competing priorities, and where they may have had limited training in case recognition, notification and reporting.[2] Consequently, since 2000 case notifications have been inconsistent from many health district and zone levels throughout DRC, and only a minority (~2%) of suspect cases reported nationwide have been subject to laboratory confirmation (unpublished data). Additionally, surveillance case definitions for MPX rely on recalled fever and the presence of a distinctive vesiculo-pustular rash. The occurrence of similar rash illnesses, particularly varicella, can confound case detection and the dearth of laboratory diagnostic testing hinders the ability of health care workers to improve their recognition of MPX cases through experience and feedback.

In 2010, the DRC Ministry of Health (MoH) joined with the Centers for Disease Control and Prevention (CDC) and the Kinshasa School of Public Health (KSPH) in an initiative to enhance MPX surveillance in the Tshuapa District of Equateur Province, where the annual incidence of MPX is estimated to be ~5/10,000. A pivotal component of the program is ongoing training of district and health zone personnel in surveillance methods and patient care. The components of the training program, a description of the participants, and an evaluation of training outcomes are described in this paper.

Materials and Methods

Setting

This initiative took place in Tshuapa District, a remote forested region in northwest DRC. The district is 135,000 km^2 in size with an estimated population of 1.7 million. It is divided into 12 health zones each with one central office, the Bureau Central de la Zone de santé (BCZS). There are six hospitals in the district, 15–30 health centers per zone and numerous health posts. The collaboration between the DRC MoH, CDC, and KSPH to support MPX surveillance in Tshuapa District began in October 2010.

Preparation of MPX Curriculum and Health Care Worker Training

Content for the MPX training materials was derived from the 2000 WHO MPX manual, MoH guidance documents, archived surveillance data, and subject matter experts. The training was conducted in French. Topics covered were: MPX epidemiology, transmission, clinical presentation and differential diagnosis, patient care, surveillance procedures, sample collection and transport, infection control practices, and community engagement. The training curriculum was organized into didactic presentations, where basic knowledge was imparted, and interactive sessions. During the interactive sessions participants were organized into small groups where they had opportunities for individual assessment of cases (role play), completion of case report forms, and doning and removal of personal protective equipment (PPE). Reference materials were developed and distributed to course attendees; these included MPX surveillance training manuals, a one-page clinical reference tool, and pictorial cards for field assessment of cases and community education. (Training materials are in French; please contact A. McCollum [azv4@cdc.gov] for additional details.)

Training of health care workers in the MPX curriculum took place in Boende, the capital of Tshuapa District. The first workshop occurred in February 2011 and the second in February 2012. Five supervisory personnel from each of the 12 health zones were invited to attend each event; six additional personnel from the district health office were invited in 2012. The trainings occurred over three successive days. The second training event (2012) also included a presentation of the prior year's surveillance data and performance metrics emphasizing specific areas for improvement. Personnel from each health zone were provided with case forms and sample collection kits. At the 2011 training, PPE for the investigation of suspect MPX cases was provided for use across the district. Training participants were asked to impart the information they obtained to staff in their respective health zones, but no additional resources (other than manuals, clinical reference tool guides etc.) were provided to support these activities.

Assessment Tools and Data Collection

Health care worker knowledge of key concepts in the MPX curriculum was assessed using an anonymous written survey. In addition, evaluators collected feedback from participants regarding their capacity to perform the surveillance tasks as outlined in the training curriculum. Survey questions were composed in English and then translated into French and reviewed for content by Congolese medical personnel from KSPH and the MoH. The survey was administered on the first day of training and repeated on the last day following completion of the educational program. On the first day of training, each participant was provided with a notebook. To preserve anonymity, participants were instructed to use the unique code written in the notebook as their identifier on both the pre- and post-training evaluation surveys.

Several performance metrics for surveillance were assessed by comparing measures from the 5 month period prior to the first training event (October 2010 through February 2011) to those obtained during the 12 month period following. Case notification and report data were obtained from MoH's surveillance reports. The number of investigated and confirmed cases was extracted from the MPX case form and laboratory results datasets.

Analysis Methods

Survey data were analyzed based on affirmative responses. Pre- and post-training tests were matched based on respondent ID number; unmatched surveys were excluded from the analysis of training effectiveness. Comparisons of responses pre- and post-training were calculated with a McNemar's Test to account for matched-pair data. Surveillance outcomes were analyzed using Pearson's Chi-Square test. A *p*-value of <0.05 was considered statistically significant. All statistical analysis was performed in SAS v9.3.

Results

Characteristics of Trainees

The MPX training was attended by 59 healthcare workers in 2011 and 67 in 2012. Attendees included doctors, nurses and community health care workers primarily in supervisory roles at a BCZ (Table 1). Most community health care worker attendees were 'Animateurs Communautaires', non-medically trained individuals who oversee a network of volunteers called "Relais Communautaires".

Evaluation of Trainee Knowledge

The proportion of correct trainee responses to questions regarding MPX symptoms, patient care, and specimen collection increased upon completion of both of the trainings (Table 2). Identification of four cardinal symptoms of MPX (febrile prodrome, lymphadenopathy, deep-seated firm lesions, and well-circumscribed lesions) improved significantly following training. On the 2012 pretest, 60.9% (28/46) of health care workers who self-identified as having attended the MPX training 2011 were still able to identify all four symptoms. Upon training completion in both years, significantly fewer health care workers selected characteristic findings of varicella—superficial lesions and lesions of different stages— as symptoms of MPX.

Regarding management of MPX patients, understanding the need to isolate patients suspected of having MPX was almost universal prior to training (both years). In contrast, recognition of the need to ensure that patients have proper nutrition, hydration and clean skin, improved significantly after training both years. After the initial training in 2011, there was no increase in health care worker recognition that a mask should be placed on MPX patients when possible. This feature of care was emphasized in the 2012 training and selection of this response increased significantly from 11 (19.0%) to 30 (51.7%), *p*-value = <0.001.

Among training attendees, identification of vesicle fluid and lesion crusts as the preferred specimens for MPX testing improved significantly following the 2011 training, and fewer health care workers erroneously selected blood as a preferred specimen (*p*<0.001) (Table 2). Knowledge of correct sample types remained high at the outset of the year-two training with an even greater reduction in the number of health care workers who selected blood as the best specimen after the training (2 trainees, 3.3%).

Measures of Surveillance Impact

The proportion of suspect MPX cases for which investigation and specimen collection was carried out significantly increased following the 2011 training. During the 5 months prior to the 2011 training, 359 notifications of suspected cases of MPX were made from Tshuapa to the MoH; 24 of these (6.7%) were investigated. During the 12 months after the training, 277 of 608 suspected cases were investigated (37.3%), a significant increase (*p*<0.001)(Table 3).

In addition, the collection of preferred specimen types— crusts and swabs as opposed to blood— increased significantly following training, and very few blood specimens were collected. The proportion of suspected cases which were confirmed as MPX through laboratory testing (performed at the National Institute for Biomedical Research in Kinshasa), however, remained essentially unchanged, 20.1% (5/24) to 23.3% (60/257).

Barriers to Investigation of Suspect MPX Cases

When asked to identify impediments to performing case investigations, trainees from the 2012 session recounted difficulties ranging from logistical barriers to personal safety concerns (Table 4). Only 3 of 65 (4.6%) respondents suggested that there are no barriers. Other respondents highlighted multiple barriers, including a lack of investigation supplies (case forms, sample kits, PPE), cases not seeking care at health facilities, the unavailability of logistical resources (most importantly fuel but also basic conveyances), and insufficient training of lower level health personnel. Additional feedback obtained through unstructured discussion sessions suggested that lack of motivation (including financial compensation), non-reimbursement of expenses, difficult terrain, and a lack of availability of medications to ameliorate patient symptoms also hinder completion of surveillance tasks. The absence of reliable communication infrastructure was also noted as being a deterrent to both the timely initiation of case investigations and notification of District staff. Cellular communication is not available in all health zones; however, radiophones are situated in each health zone (but only in the capital, and some were reported to be in disrepair.)

Personal safety was also identified as a hindrance to performing case investigations. The majority of health care workers surveyed (42/59, 71.2%) reported being fearful of becoming infected with MPX when performing surveillance and clinical duties. Smallpox vaccination, which provides some protection against infection with MPXV was discontinued in DRC by 1980. Among attendees at the 2012 training, 48/49 (81.4%) reported having received smallpox vaccination prior to 1980. The majority of these individuals (33/48, 68.7%) still expressed concerns about becoming infected while investigating or caring for a MPX patient. Only 45% of trainees queried in 2012 (27/60) indicated that they *always* have the appropriate PPE for collection of specimens, while 51.7% (31/60) reporting *sometimes* having PPE and 3.3% (2/60) reported *never* having PPE.

Among respondents who attended the 2012 training 96% (44/46) reported that they had provided MPX training to other health care workers and 91.3% (42/46) reported using the reference manual within the last year.

Discussion

In severely resource poor settings there are many challenges to disease detection and response. The small health care workforce in Tshuapa District is tasked with conducting public health surveillance over vast areas with underdeveloped infrastructure, while simultaneously providing patient care with a minimal arsenal of medical supplies. Nevertheless, effective disease surveillance and response remains a priority given the high risk of outbreaks of epidemic-prone illnesses in this region. The enhanced MPX surveillance program demonstrates that training of local health care workers and provision of simple surveillance tools can increase clinical knowledge and surveillance acuity. The MPX curriculum successfully transferred knowledge integral to the detection and care of patients with MPX to front line health care workers. Correct identification of MPX symptoms and appropriate patient care improved demonstrably following each workshop.

To-date, however, health care worker training in Tshuapa has been primarily limited to formal training of the supervisory staff of each health zone. These individuals provided onward, informal, instruction to other health care workers, but competing work demand and inadequate monetary resources limited their ability to expand training activities to reach all health zone staff. Tshuapa residents who do not live in close proximity to their zone's hospital are less likely to be evaluated by a health care worker who is knowledgeable about MPX and surveillance procedures. Additional training of staff beyond those in supervisory roles (such as those at the health centers and health posts) may increase the number of cases investigated, improve correct application of the case definition, and provide better patient care. Such trainings could be incorporated into routine field supervision activities. Condensed training resources and quick reference guides that could be used for short seminars or informal field instruction should be distributed for this purpose. Given that many individuals who engage in MPX surveillance and patient care do not have formal medical training, the materials should be designed for individuals with a basic level of knowledge and limited to key points regarding prevention, diagnosis, patient care, disinfection, and surveillance.

Recognition of MPX symptoms improved significantly after both trainings, yet only about a quarter of the suspected cases for which testing was performed were ultimately confirmed as MPXV infections. Most of the remaining cases were ultimately diagnosed as varicella (*unpublished data*). Multiple factors could be contributing to this lack of clinical diagnostic accuracy. For one, an insufficiently specific surveillance case definition would result in over diagnosis of MPX given concomitant circulation of other clinically-similar febrile rash illnesses. The surveillance case definition for MPX in DRC is currently optimized for sensitivity, but it is likely that specificity could be enhanced. A second factor potentially contributing to diagnostic inaccuracy may be health care worker misapprehension of case definition elements that should engender diagnostic specificity. For example, the rash description is highly characteristic for *Orthopoxvirus*-associated infection such as MPX, but learning how to distinguish subtle visual characteristics of a MPX rash from those of varicella requires experience, training, and feedback. In the early stages of the rash, it is difficult to distinguish MPX from other febrile rash illnesses; sometimes the best clinical perception can be incorrect. The collection of images of patients' rashes could aid clinical diagnosis and facilitate our understanding of how well the case definition is being applied by health care workers. Also, timely transmission of laboratory results to health care workers could provide important diagnostic feedback to help improve their ability to discriminate between MPX and chickenpox.

Following the provision of training and investigative resources in 2011, the proportion of cases investigated increased markedly, over 6-fold. Case investigations are a critical aspect of disease monitoring as an investigation entails the collection of diagnostic specimens and completion of case report forms. In the absence of these elements, MPX surveillance data are less informative and less accurate. Surveillance accuracy can also be improved by the collection of optimal diagnostic specimens—lesion-derived material rather than blood. This is beneficial for two reasons. First, lesion-derived specimens harbor detectable evidence of MPXV infection for a longer period of time during illness than does blood (viremia is a transitory state during illness,[15]) and, second, collection of lesion material is less invasive than blood collection and is less prone to result in iatrogenic complications.

While the proportion of suspected cases investigated increased to 46.0% after health care workers were trained and provided with material resources, investigations still fell short of the MOH’s goal of 80%. Multiple impediments to investigation were highlighted by the workers during the evaluation session. Lack of PPE, too few bicycles, the absence of motorcycles, fuel, and reimbursement for expenses incurred were commonly emphasized as major barriers to the completion of MPX surveillance tasks. These limitations are systemic and are likely to have a negative impact on most IDSR activities in Tshuapa District and throughout DRC.

Lastly health care workers sited concerns for personal safety, compounded by a lack of reliable access to PPE, as being an important obstacle to investigating monkeypox cases. Monkeypox is communicable and health care workers who have direct contact with monkeypox patients are at risk for disease acquisition. Strict adherence to respiratory and contact precautions can mitigate infection risks, as can vaccination.[16–18] Vaccination (re-vaccination) of health care workers with second generation or newer vaccines should be considered in areas of high transmission risk such as is seen in the Tshuapa Health District of DRC.[19–21] (Third generation smallpox vaccines have improved safety profiles but undemonstrated efficacy under conditions of natural disease transmission.[22]) Health care workers should also be consistently provided with access to basic PPE. While introducing additional costs, this action alone would almost certainly yield broad ranging collateral benefits throughout the health care sector.

There are several important limitations to this study that preclude our ability to derive inferences relevant to either the effectiveness of secondary training activities or the longer term impact of training on case ascertainment and reporting. The majority of course participants were supervisory health care workers. Participants were provided with materials to support training of staff under their supervision, but we did not track or evaluate secondary training initiatives as part of this project. This may have biased our interpretation of study findings, as supervisory health care workers are likely to be better prepared to benefit from didactic training than subordinates who may have less formal education. Finally, we assessed performance metrics for surveillance in the immediate aftermath of training exercises when retention and recall of procedures are apt to be their highest. Assessment of performance metrics at an additional time point further removed from the period of training is warranted.

Conclusion

The 1998 IDSR established a conceptual framework for integrating infectious disease surveillance, including response and action, with the intent of developing efficient flexible systems that would be responsive to established and emerging public health threats.[1,2] Health care worker training and the provision of resources were identified as critical support functions to this basic approach. We have demonstrated that the MPX curriculum developed for this initiative was effective in transferring knowledge and was associated with improved detection of human MPX cases. Similar models for training local health care workers and the provision of simple investigation tools may be useful for improving surveillance and response to other infectious diseases of epidemic potential in resource-poor settings in line with the model outlined for IDSR in Africa. Ultimately, however, monkeypox will not be adequately controlled until there is better understanding of zoonotic transmission risks, geographical distribution, and patterns of inter-human transmission. Additional basic resources will be needed to put best practices into action.

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Authors' Statements

This project (CDC 020911DT) was reviewed prospectively in February 2011 by CDC's human subjects research advisory unit within the National Centers for Emerging and Zoonotic Infectious Diseases and was determined to be a non-research activity as defined by 45 CFR 46.102(d); therefore IRB review was not required.

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Table 1

Characteristics of MPX Training Evaluation Respondents, Tshuapa, DRC, 2011, 2012.

Characteristic	2011*		2012*	
Mean age, n(range)	39	(29–54)	41	(28–64)
Male, n(%)	56	95%	64	96%
Profession, n(%)				
Physician	18	31%	24	36%
Nurse	30	51%	27	40%
Community health care worker	11	19%	16	24%

*N=59 (2011); N=67 (2012)

Table 2

Evaluation of Health care worker Knowledge Prior to and After MPX Surveillance Training Sessions, Tshuapa, 2011, 2012.

	2011					2012				
	Pre-Test n (%)		Post-Test n (%)		*p*-value	Pre-Test n (%)		Post-Test N (%)		*p*-value^
Monkeypox Symptoms										
Febrile prodrome	52	91.2%	52	91.2%	1.00	48	87.3%	55	100.0%	0.01
Lymphadenopathy	27	47.4%	51	89.5%	<0.001	38	69.1%	50	90.9%	0.00
Deep seeded firm lesions	22	38.6%	53	93.0%	<0.001	42	76.4%	54	98.2%	0.00
Well circumscribed lesions	26	45.6%	37	64.9%	0.03	35	63.6%	52	94.5%	<0.001
All 4 symptoms (above)	10	17.5%	32	56.14%	<0.001	26	47.3%	48	87.3%	<0.001
Symptoms Not Associated with Monkeypox										
Itching	17	29.8%	22	38.6%	0.28	12	21.8%	6	10.9%	0.61
Rash starts on abdomen	17	29.8%	13	22.8%	0.35	6	10.9%	5	9.1%	0.74
Superficial lesions	12	21.1%	4	7.0%	0.02	5	9.1%	1	1.8%	0.05
Lesions at different stages	33	57.9%	10	17.5%	<0.001	15	27.3%	4	7.3%	0.01
Patient Care (practice encouraged)										
Isolate	58	100.0%	57	98.3%	0.32	57	98.3%	57	98.3%	1.00
Keep skin clean and dry	28	48.3%	48	82.8%	<0.001	37	63.8%	51	87.9%	0.00
Ensure proper nutrition & hydration	35	60.3%	52	89.7%	<0.001	44	75.9%	55	94.8%	0.00
Put a mask on patient when possible	11	19.0%	11	19.0%	1.00	11	19.0%	30	51.7%	<0.001
Patient Care (practice discouraged)										
Encourage family to sleep with patient	1	1.7%	2	3.4%	0.32	2	3.4%	3	5.2%	0.65
Treat at home with multiple caregivers	5	8.6%	13	22.4%	0.03	19	32.8%	12	20.7%	0.11
Preferred Specimen Types										
Vesicle fluid	30	52.6%	52	91.2%	<0.001	51	78.5%	57	93.4%	0.01
Crust	47	82.5%	57	100.0%	<0.01	52	80.0%	57	93.4%	0.06
Blood	51	89.5%	20	35.1%	<0.001	26	40.0%	2	3.3%	<0.001

Not all attendees completed every question on pre- and post-training surveys, unmatched responses were excluded from analysis.

^McNemar's Test was applied to test the difference in affirmative responses pre- and post- training.

Table 3

Measures of Surveillance Impact Following the Initial Health care worker Training Event, 2011.

	Before 2011 Training* n/N	(%)	After 2011 Training* n/N	(%)	*p*-value
Cases investigated/suspect cases	24/359	6.7	227/608	37.3	<0.001
Type of sample collected†					
Crust	5/24	20.8	128/277	46.2	<0.001
Swab	6/24	25.0	182/277	65.7	<0.001
Blood	23/24	95.8	10/277	3.6	<0.001
Cases confirmed/suspect cases	5/24	20.1	60/257‡	23.3	0.780

* ‘Before’ period spans October 2010 through February 2011, the five months prior to the 2011 training; ‘After’ period spans the 12-month timeframe after the initial training, March 2011 through February 2012.

† More than one specimen may be collected per suspect case.

‡ Testing was performed at the National Institute for Biomedical Research in Kinshasa using quantitative PCR assay designed to detect Orthopoxvirus DNA.[23]

Table 4

Frequency of Health care worker-identified Barriers to Performing MPX Case Investigations, Tshuapa, 2012.

Barrier to Investigation*	n†	(%)
Not enough sampling kits	29	(44.6)
Not enough case forms	20	(30.8)
Not enough PPE‡	29	(43.1)
Cases did not seek health care at clinic or hospital	24	(36.9)
Patient refused interview/specimen collection	9	(13.8)
Health care worker unsure of procedures	11	(16.9)
Lack of fuel	23	(35.4)
Other logistical barriers	16	(24.6)

*Additional barriers emphasized in key informant interviews include: lack of motivation, non-reimbursement of expenses, inadequate communication infrastructure, lack of motorcycles, and vast, difficult terrain.

†N=65.

‡Personal protective equipment (PPE) may include: gloves, eye protection, face mask etc.