Survey of reported eye injuries from handheld laser devices in Canada

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ABSTRACT • RÉSUMÉ

Background: Unprotected exposure to handheld lasers can cause temporary or permanent vision loss depending on the laser classification.

Objective: To evaluate the occurrence of, and details associated with, reported eye injuries resulting from handheld lasers.

Methods: A 14-item questionnaire developed by Health Canada was distributed by the Canadian Ophthalmological Society and the Canadian Association of Optometrists to their respective members.

Results: Questionnaire data were available from 909 respondents (263 ophthalmologists; 646 optometrists). Response rates were 23.1% and 12.7%, respectively. Validated data were available from 903 respondents, where 157 (17.4%) reported encountering at least 1 eye injury from a handheld laser. A total of 318 eye injuries were reported with an annual increase of 34.4% (95% CI 21.6%−48.7%, $p < 0.0001$) between 2013 and 2017. When respondents reported on only their most severe case, 77 (53.5%) reported vision loss that ranged from minor to severe, which persisted for more than 6 months in 42.9% of the cases. Another 59 (41.3%) noted the presence of retinal damage. The prevalence of eye injuries from handheld lasers was higher for males (82.5%) than females (14.0%), more frequent among those under the age of 50 years, and occurred predominately as a result of exposure from another person (67.6%) versus self-induced (26.1%) ($p < 0.0001$).

Conclusions: Although this pilot study permits insight into the potential prevalence of injuries resulting from exposure to handheld laser devices in Canada, the results are not nationally representative. These findings support additional surveillance activities that may inform risk assessment and potential risk management strategies.

Contexte: L'exposition non protégée aux lasers portatifs peut entraîner une perte de vision temporaire ou permanente, selon la classification du laser.

Objectif: Évaluer l'occurrence des lésions oculaires associées aux lasers portatifs et en décrire les caractéristiques.

Méthodes: Un questionnaire en 14 rubriques de Santé Canada a été distribué par la Société canadienne d'ophtalmologie et l'Association canadienne des optométristes à leurs membres respectifs.

Résultats: Quelque 909 personnes ont répondu au questionnaire (263 ophtalmologistes et 646 optométristes; taux de réponse de 23,1 % et de 12,7 %, respectivement). On a disposé de données validées pour 903 répondants, dont 157 (17,4 %) ont signalé avoir eu à traiter au moins un cas de lésion oculaire causée par un laser portatif. Au total, 318 lésions oculaires ont été signalées, d'où une hausse annuelle de 34,4 % (IC à 95 %: 21,6 %-48,7 %; $p < 0,0001$) entre 2013 et 2017. Lorsque les répondants se limitaient uniquement au cas le plus grave, 77 (53,5 %) ont signalé une perte de vision s'échelonnant de mineure à grave qui a duré pendant plus de 6 mois dans 42,9 % des cas. De même, 59 autres répondants (41,3 %) ont mentionné la présence d'une lésion rétinienne. La prévalence de lésions oculaires dues aux lasers portatifs était plus élevée chez les hommes (82,5 %) que chez les femmes (14,0 %), et plus élevée chez les sujets de moins de 50 ans; de plus, l'exposition au rayon laser était surtout provoquée par une autre personne (67,6 %) plutôt qu'auto-induite (26,1 %; $p < 0,0001$).

Conclusions: Bien que cette étude pilote donne une idée de la prévalence potentielle des lésions secondaires à l'exposition à des lasers portatifs au Canada, les résultats ne sont pas représentatifs de l'ensemble du pays. Ils étayent le besoin de proposer des activités de surveillance supplémentaires dans l'idée de mettre au point des stratégies d'évaluation et de prise en charge du risque potentiel.

In recent years there has been an increasing assortment of consumer handheld laser devices available to Canadians due to decreased production costs, global internet marketing trends, and the ease of online purchasing. Individuals may be unaware of the hazard associated with different laser classifications and the potential for high-powered handheld laser devices to cause serious harm, particularly to the visual system.

Exposure to handheld laser devices may cause temporary or permanent effects to the eye, ranging from visual interference to impaired vision and blindness, depending on the classification of the laser device. Lasers devices can be classified according to an international standard[1] based on a number of factors such as the accessible exposure level, the wavelength of the laser light, the emission duration, and the irradiance

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profile of the laser beam. The classification of lasers from lowest to highest hazard level are as follows: class 1, 1C, 1M, 2, 2M, 3R, 3B and 4. Class 1 lasers are not hazardous and pose no known health risk. Class 2 lasers represent a low risk as they are only hazardous if one stares deliberately into the beam for extended periods of time. Class 1C, 1M, 2M, and 3R lasers can be hazardous if not used safely, but the risk of injury remains relatively low. Class 3B and 4 are the most hazardous types of lasers and pose significant health risks, such as permanent eye damage or skin burns if used without appropriate personal protective equipment, or adequate knowledge regarding risks. Class 3B and 4 consumer handheld laser pointers are prohibited in Canada from being sold, imported, advertised, and (or) manufactured under sections 7 and 8 of the *Canada Consumer Product Safety Act*.[2] Furthermore, labelling, packaging, or advertising any laser device in a manner that is false, misleading, or deceptive is a contravention of section 5 of *Radiation Emitting Devices Act*.[3] As of 2012, the Canadian Border Services Agency (CBSA) has been assisting Health Canada to identify and intercept handheld consumer class 3B and 4 laser pointers to prevent their entry into the country. CBSA continues to intercept high-powered handheld laser devices; however, mislabeling may undermine efforts to identify and prevent such devices from entering the country, and possession of these devices could result in an increased prevalence of eye injuries in Canada.

Published case reports of handheld laser-induced eye injuries worldwide in recent years underscore the risk associated with such devices.[4–6] These reports likely represent a small portion of the total injuries sustained as most incidents will not be published in the case study literature. In addition, eye injuries may not be directly attributable to a particular exposure incident.[7] Although Health Canada does track voluntary incident reports regarding handheld laser eye injuries, as of December 2018 only one report of an eye injury from a handheld laser device has been received. Underreporting may be due to the injury resolving itself quickly, feelings of embarrassment, fear of disciplinary action, and (or) simply not being aware of the incident reporting system. (Information on how to report an incident involving a consumer product or cosmetic is available on the following Government of Canada website http://health.canada.ca/en/health-canada/services/consumer-product-safety/advisories-warnings-recalls/report-incident-involving-consumer-product-a.html)

As the number of handheld laser device-induced eye injuries in Canada is largely unknown, the primary objective of this study was to estimate the occurrence of eye injuries resulting from handheld laser devices through a survey of health care professionals from the Canadian Ophthalmological Society (COS) and the Canadian Association of Optometrists (CAO).

Methodology

Questionnaire

The English version of the questionnaire is provided as supplemental material. A series of 14 questions was developed using the SurveyMonkey platform in consultation with practice leaders from the COS and the CAO. The survey questions were aimed at determining the occurrence and severity of handheld laser device-induced eye injuries. Several questions required that respondents restrict answers to the patient they considered to represent the most severe case. Therefore, the most severe case will vary in the severity of injury and duration of vision loss. The degree of vision loss is represented in the form of the internationally accepted Snellen fraction. As such, minor vision loss is expressed as 20/40 or better, moderate vision loss is expressed with ranges of 20/50 to 20/80, severe vision loss is 20/100 to 20/400, and disabling vision loss with higher denominator values is associated with having a substantial impact on self-care and activities of daily living. Questions regarding characteristics of the laser device (i.e., power output, colour of beam, and classification) were also included. Additional information was provided to respondents on how laser-induced eye injuries can be reported to Health Canada to encourage increased voluntary reporting in the future. The questionnaire completion duration was approximately 3 to 5 minutes, and participation was voluntary.

Respondents and survey promotion

All responses were anonymous (no tracking of internet protocol or email address) and no identifying information was collected on COS/CAO respondents or the individuals with eye injuries. Access to the online survey was provided through their professional associations. All respondents were asked to complete the questionnaire, regardless of whether they had ever seen a patient with an eye injury resulting from a handheld laser device. In addition to completing the questionnaire, respondents were presented with a comment box within the survey to allow an opportunity for additional information or context to be provided. Participation was voluntary; however, before launching the survey, initiatives were carried out to stimulate interest and increase survey response rates. One such activity involved presentations to COS and CAO members, which served to disseminate information about the upcoming Health Canada survey. Additionally, all members received communication from their professional associations notifying them of the upcoming survey and encouraging them to participate. The invitation to participate in the survey was sent by the professional organizations to all members of the COS (n = 1138) on June 6, 2018, and to all members of the CAO (n = 5105) on June 14, 2018. The survey response period remained open until August 1, 2018. Reminder emails were sent by the respective professional organizations at 2-week intervals over the course of the survey data collection.

Statistical analysis

Count data were extracted from SurveyMonkey and imported into Microsoft Excel and SAS (Enterprise Guide [EG] 5.1 2012). All cross tabulations, χ^2 tests, Fisher's exact test, and Poisson regression were conducted using SAS (EG

Table 1—Ophthalmologist and optometrist response distribution by province/territory

Province/Territory	Respondents n (%) COS	CAO	Combined n (%)*	Canadian Population Distribution, 2017 (%)†
Alberta	26 (9.9)	84 (13.0)	110 (12.1)	11.7
British Columbia	42 (16.0)	78 (12.1)	120 (13.2)	13.1
Manitoba	15 (5.7)	17 (2.6)	32 (3.5)	3.6
New Brunswick	5 (1.9)	17 (2.6)	22 (2.4)	2.1
Newfoundland	4 (1.5)	8 (1.2)	12 (1.3)	1.4
Northwest Territories	0 (0.0)	0 (0.0)	0 (0.0)	0.1
Nova Scotia	15 (5.7)	21(3.3)	36 (4.0)	2.6
Nunavut	0 (0.0)	3 (0.5)	3 (0.3)	0.1
Ontario	88 (33.5)	262 (40.6)	350 (38.5)	38.7
Prince Edward Island	1 (0.4)	4 (0.6)	5 (0.6)	0.4
Quebec	59 (22.4)	121(18.7)	180 (19.8)	22.9
Saskatchewan	8 (3.0)	30 (4.6)	38 (4.2)	3.2
Yukon	0 (0.0)	1 (0.2)	1 (0.1)	0.1
Total	263	646	909	–

COS, Canadian Ophthalmological Society; CAO, Canadian Association of Optometrists.
*The percentages for combined responses are calculated based on the total number of responses (e.g., 909).
†Statistics Canada, 17-10-0005-0.1.

5.1 2012). Statistical significance was specified as a $p < 0.05$. Where pairwise comparisons were carried out, Bonferroni corrections were used in order to maintain the type I error rate at less than 0.05.

Results

Estimated membership response rates

A total of 263 survey responses were received from COS respondents (1138 total members), and 646 survey responses were received from CAO respondents (5105 total members), representing a membership response rate of 23.1% and 12.7%, respectively.

Distribution of respondents

Table 1 shows the distribution of respondents by province/territory for the 2 professional bodies. The distribution aligned well with the 2017 national population distribution reported by Statistics Canada.[8]

Reported eye injuries from handheld laser devices

Respondents were asked: "*Have you ever had a patient present to you with an eye injury resulting from exposure to a handheld laser (such as a laser pointer or similar device)?*" Sample photographs of typical handheld laser devices were shown beside this question. In addition, respondents were instructed to not report eye injuries from medical or cosmetic laser procedures. This question was used as a filter whereby respondents with affirmative responses were screened in for more detailed questions. Respondents who answered "no" to this question were not presented with any further questions, but they were provided additional information on how to report future eye injuries to Health Canada.

As shown in Table 2, a total of 50 out of 261 ophthalmologist respondents (19.2%) and 107 out of 642 optometrist respondents (16.7%) reported they had a patient present with a handheld laser eye injury.

Table 2—Number of respondents who had a patient present with an eye injury from a handheld laser device

Eye Injury Present	Respondents n (%) COS	CAO	Combined n (%)*
Yes	50 (19.2)	107 (16.7)	157 (17.4)
No	211 (80.8)	535 (83.3)	746 (82.6)
Total†	261	642	903
Missing	2	4	6

COS, Canadian Ophthalmological Society; CAO, Canadian Association of Optometrists.
*The percentages for combined responses are calculated based on the total number of non-missing responses (e.g., 903).
†Totals do not include missing responses. Missing responses are generated by questions that were skipped by the participant. In this survey, 6 participants only completed the first question.

Yearly pattern in laser-induced eye injuries

Respondents were asked to indicate the number of patients who presented to them with a laser-induced eye injury per year. Ophthalmologists and optometrists responses combined yielded a total of 318 cases in which a patient presented with an eye injury from a handheld laser device (Fig. 1). Fitting a Poisson regression model to the number of laser-induced eye injuries occurring each year between 2013 to 2017 indicated that the observed number of injuries increased by a factor of 1.344, or the observed number of laser-induced injuries increased by 34.4% each year between 2013 and 2017 (95% CI 21.6%−48.7%, $p < 0.0001$). There was an apparent drop between January 1, 2018 and August 1, 2018; however, this is most likely a result of the collection data representing only 8 months and not a full calendar year, as the survey was closed on August 1, 2018.

Characterization of eye injuries from handheld laser devices

The survey included questions to assess the severity and duration of vision loss and the incidence/location of retinal damage (see questions 4−7, Supplemental Material). The responses to these questions rely upon physical examination of the patient by the ophthalmologist or optometrist, and therefore these results can be viewed with a high degree of

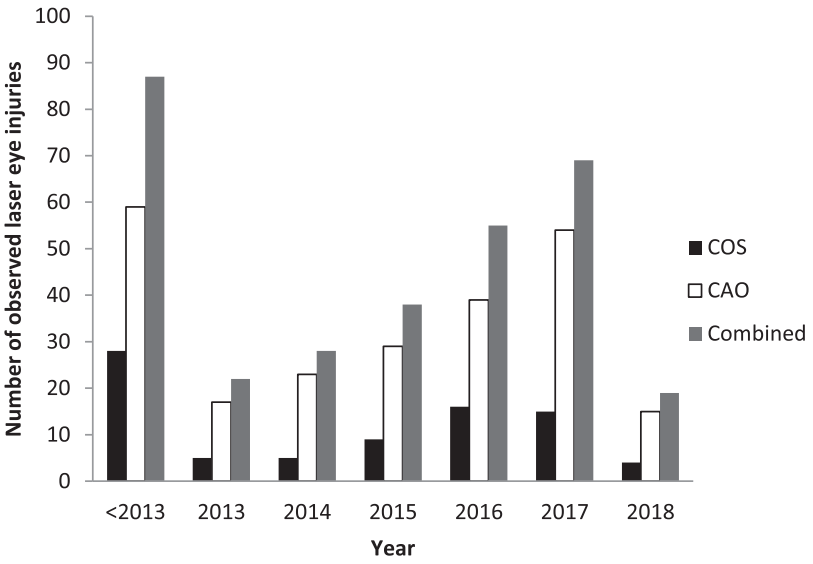

Fig. 1—Number of patients reporting to practitioners with a handheld laser eye injury per year. The observed annual increase was 34.4% between the years 2013 and 2017. Each year between 2013 and 2017 covers the period between January 1 to December 31 inclusive. The year 2018 covers the period between January 1 and August 1. Responses were missing from 12 participants (3 COS, 9 CAO) who had a patient present to them with an eye injury from a handheld laser device.
COS, Canadian Ophthalmological Society; CAO, Canadian Association of Optometrists.

confidence. For these questions, respondents were asked to consider *only the most severe case* that they had observed.

Severity of vision loss. According to Table 3, 77 ophthalmologists and optometrists indicated the patient they treated with the most severe eye injury from a handheld laser device experienced vision loss (ranging from minor to disabling in severity). The degree of vision loss is represented in the form of the internationally accepted Snellen fraction. Results showed that most cases of vision loss ranged from minor (36.8%) to moderate (9.7%).

Duration of vision loss. The results shown in Table 4 represent the reported duration of vision loss for the most severe case. The vast majority (42.9%) of respondents indicated that vision loss persisted for 6 months or more.

Considering a cross tabulation of severity of vision loss and duration of vision loss (Table 5), we note that the majority of individuals with minor vision loss (20/40 or better) or moderate vision loss (20/50 to 20/80) reported this type of impairment for more than 6 months (16/53 or 30.2% and 9/14 or 64.3%, respectively). Also, the majority of those who reported experiencing vision loss for more than 6 months were individuals with minor vision loss (16/33 or 48.5%). As shown in Table 5, there was no statistical association observed between severity of vision loss and the duration of vision loss ($p > 0.05$). Furthermore, no association was observed when the duration of vision loss categories was collapsed to less than 1 week, 1 week to 6 months, and greater than 6 months (data not shown).

The association between severity of vision loss and duration of vision loss was not statistically significant ($p > 0.05$). Minor vision loss was defined as 20/40 or better; moderate vision loss was defined as 20/50 to 20/80; severe vision loss was defined as

Table 3—Severity of vision loss from handheld laser device, most severe case per respondent

	Respondents n (%)		
Severity of Vision Loss	COS	CAO	Combined n (%)*
None	16 (34.8)	51 (52.0)	67 (46.5)
Minor	17 (37.0)	36 (36.7)	53 (36.8)
Moderate	7 (15.2)	7 (7.1)	14 (9.7)
Severe	6 (13.0)	3 (3.1)	9 (6.3)
Disabling	0 (0.0)	1 (1.0)	1 (0.7)
Total	46	98	144
Missing	4	9	13

COS, Canadian Ophthalmological Society; CAO, Canadian Association of Optometrists.
*The percentages for combined responses are calculated based on the total number of non-missing responses (e.g., 144).
†Totals do not include missing responses. Missing responses are generated by questions that were skipped by the participant. Minor vision loss was defined as 20/40 or better. Moderate vision loss was defined as 20/50 to 20/80. Severe vision loss was defined as 20/100 to 20/400. Disabling vision loss was defined as substantial impact on self-care and activities of daily living.

Table 4—Duration of vision loss from handheld laser device, most severe case per respondent

	Respondents n (%)		
Duration of Vision Loss	COS	CAO	Combined n (%)*
<2 days	1 (3.3)	4 (8.5)	5 (6.5)
2 days to 1 week	3 (10.0)	6 (12.8)	9 (11.7)
1 week to 1 month	4 (13.3)	3 (6.4)	7 (9.1)
1 month to 3 months	6 (20.0)	2 (4.3)	8 (10.4)
3 months to 6 months	1 (3.3)	3 (6.4)	4 (5.2)
>6 months	12 (40.0)	21 (44.7)	33 (42.9)
Unknown	3 (10.0)	8 (17.0)	11 (14.3)
Total†	30	47	77
No visual impairment	16	51	67
Missing	4	9	13

COS, Canadian Ophthalmological Society; CAO, Canadian Association of Optometrists.
*The percentages for combined responses are calculated based on the total number of non-missing responses (e.g., 77).
†Totals do not include missing responses. Missing responses are generated by questions that were skipped by the participant.

Table 5—Relationship between severity and duration of vision loss, most severe case per respondent

	Duration of Vision Loss							
Severity of Vision Loss	<2 Days	2 Days to 1 Week	1 Week to 1 Month	1 Month to 3 Months	3 Months to 6 Months	More than 6 Months	Unknown	Totals
None	0	0	0	0	0	0	0	0
Minor	4	7	5	6	4	16	11	53
Moderate	1	2	0	2	0	9	0	14
Severe	0	0	2	0	0	7	0	9
Disabling	0	0	0	0	0	1	0	1
Totals	5	9	7	8	4	33	11	77

20/100 to 20/400. Disabling vision loss was defined as substantial impact on self-care and activities of daily living.

Location of retinal damage. Vision loss is most likely to occur when the retina is damaged, particularly at the fovea of the retina. For the most severe cases observed by the ophthalmologist or optometrist, 59 (41.3%) respondents (COS n = 24; CAO n = 35) confirmed the presence of retinal damage and 21 (14.7%) (COS n = 6; CAO n = 15) indicated retinal damage was uncertain/inconclusive. As expected, it was found that there was a strong association between the presence/absence of a retinal damage and severity/lack of vision loss ($p < 0.0001$) (data not shown).

Respondents that reported evidence of retinal damage were subsequently asked to identify where on the retina the damage was observed. There were 11 cases where more than one area of damage was identified. Table 6 shows that the fovea and macula were equally likely to be affected. Respondents reported 32 cases of vision loss from handheld laser devices where physical damage was observed to the retina and, more specifically, the fovea.

There was a strong association between location of retinal damage and severity of vision loss ($p < 0.0001$). As shown in Table 7, the majority of cases with fovea (17/22) and macula (12/24) damages resulted in minor vision loss. It is important to note that the scientific literature indicates that vision loss can also be experienced from nonretinal lesions due to hemorrhage.[9,10]

Table 6—Location of retinal damage in patients experiencing vision loss from handheld laser devices, most severe case per respondent

	Respondents n (%)		
Area of Retinal Damage	COS	CAO	Combined n (%)*
Fovea	8 (33.3)	14 (40.0)	22 (37.3)
Macula	9 (37.5)	15 (42.9)	24 (40.7)
Periphery	0 (0.0)	2 (5.7)	2 (3.4)
Fovea and macula	6 (25.0)	3 (8.6)	9 (15.3)
Fovea and periphery	0 (0.0)	0 (0.0)	0 (0.0)
Macula and periphery	0 (0.0)	1 (2.9)	1 (1.7)
Fovea, macula, and periphery	1 (4.2)	0 (0.0)	1 (1.7)
Number of retinal damages†	24 (53.3)	35 (35.7)	59 (41.3)
No retinal damage	15 (33.3)	48 (49.0)	63 (44.1)
Uncertain/Inconclusive	6 (13.3)	15 (15.3)	21 (14.7)
Total†	45	98	143
Missing	5	9	14

COS, Canadian Ophthalmological Society; CAO, Canadian Association of Optometrists.
*The combined percentage of the different retinal damages (fovea, macula periphery) are based on the "Number of retinal damages" reported (59), whereas the combined percentage of "Number of retinal damages," "No retinal damage," and "Uncertain/Inconclusive" results are based on the total responses (143). Combined percentages do not include missing responses.
†Number of retinal damages and total do not include missing responses. Missing responses are generated by questions that were skipped by the participant.

Table 7—Association between area of retinal damage and severity of vision loss, most severe case per respondent

	Severity of Vision Loss					
Area of Retinal Damage	Minor	Moderate	Severe	Disabling	None	Total
Fovea	17	3	2	0	0	22
Macula	12	8	3	0	1	24
Periphery	1	0	0	1	0	2
Fovea and macula	4	1	4	0	0	9
Fovea and periphery	0	0	0	0	0	0
Macula and periphery	0	0	0	0	1	1
Fovea, macular, and periphery	0	1	0	0	0	1
Uncertain/Inconclusive	9	0	0	0	12	21
Total	43	13	9	1	14	80

Minor vision loss was defined as 20/40 or better. Moderate vision loss was defined as 20/50 to 20/80. Severe vision loss was defined as 20/100 to 20/400. Disabling vision loss was defined as substantial impact on self-care and activities of daily living.

Demographics of patients experiencing eye injuries from handheld laser devices

The demographic profile of patients experiencing eye injuries from handheld laser devices was evaluated in this survey. As observed from Table 8, considering only the most severe cases, 37.1% of patients who experienced eye injuries from handheld laser devices were aged 15 to 29 years, while 28.0% were aged 2 to 14 years and 28.0% were aged 30 to 49 years. The prevalence in these age groups was considered statistically similar ($p > 0.05$) but were all significantly higher than the prevalence observed in the 50+ years age group 6.3% ($p < 0.0001$). These survey data demonstrate that children and adolescents (aged 2–14 years) as well as young adults (aged 15–29 years) are overrepresented relative to the distribution of the Canadian population with respect to prevalence of eye injuries from handheld laser devices. When responses were restricted to the most severe cases, 82.5% of patients who expe-

Table 8—Age of patient experiencing eye injury from handheld laser device, most severe case per respondent

	Respondents n (%)			
Age (Years)	COS	CAO	Combined n (%)*	Canadian Population Distribution by Age, 2017 (%)†
<2	0 (0.0)	0 (0.0)	0 (0.0)	2.1
2–14	14 (31.1)	26 (26.5)	40 (28.0)	13.9
15–29	19 (42.2)	34 (34.7)	53 (37.1)	19.4
30–49	11 (24.4)	29 (29.6)	40 (28.0)	26.8
50+	1 (2.2)	8 (8.2)	9 (6.3)	37.8
Unknown	0 (0.0)	1 (1.0)	1 (0.7)	–
Total‡	45	98	143	
Missing	5	9	14	

COS, Canadian Ophthalmological Society; CAO, Canadian Association of Optometrists.
*The percentages for combined responses are calculated based on the total number of non-missing responses (e.g., 143).
†Statistics Canada, 17-10-0005-01.
‡Totals do not include missing responses. Missing responses are generated by questions that were skipped by the participant.

rienced eye injuries from handheld laser devices were male compared to 14.0% female ($p < 0.0001$) (data not shown).

Discussion

The results of this inaugural survey demonstrate that there is evidence that eye health care professionals in Canada are being presented with patients who have sustained eye injuries, where damage to the retina has resulted from exposure to handheld laser devices. Survey respondents confirmed the presence of retinal damage for 59 of the most severe injury cases observed. This is seemingly inconsistent when compared to the 77 reported cases where the level of vision loss ranged from mild to disabling. However, 21 of the respondents selected the "uncertain/inconclusive" response category when asked to identify the location of retinal damage, which leads to speculation that at least some of these individuals may have had retinal damage that resulted in vision loss. Although 12 had no vision loss, 9 of the 21 were reported to have minor vision loss. It should also be considered that a few of the 77 cases may have had damage to extraretinal areas[8,9] and (or) that a lesion to the retina (or elsewhere) may have resolved by the time the patient was examined by the ophthalmologist or optometrist. Minor changes to the questionnaire could be made to assess damage to all areas including but not limited to the retina.

When injuries affected vision, the impairment ranged from minor to moderate in 46.5% of cases, severe in 6.3% of cases, and disabling in only 1 case. In this study, the finding that vision loss persisted for 6 months or more in 42.9% of cases was unexpected as vision loss duration would be expected to align more closely with severity of vision loss, which was predominantly minor to moderate in the current survey. It is unknown if the health care professionals estimated the duration of vision loss based upon follow-up examinations or upon their patients' self-reported history of visual acuity. In addition, there may be some ambiguity in this question. It was not clear if the question was referring to the duration of recovery of vision loss after the laser injury or to preinjury visual acuity.

When data were assessed by calendar year there was a 34.4% increase in reported handheld laser device-induced eye injuries for each successive year between 2013 and 2017. Incomplete data collection in 2018 did not permit a full analysis of what may be taking place more recently. Although the pattern in Figure 1 suggests an increased number of injuries over the years indicated, it is possible that a small fraction of the injury data represents a protracted injury that spans multiple years. It should also be noted that our survey did not query the method respondents used to recall injuries. It is acknowledged that frequency trends over time would be less precise if recall was strictly based upon memory and not historical medical record keeping.

The present study findings are largely based on respondents' accounts of their most severe cases. There were several reasons for restricting responses to the most severe eye injury. The level of detail in the questionnaire had to be balanced against the potential impact a longer survey would have had on the response rate. The aim of this survey was to restrict the questionnaire response time to less than 5 minutes. Furthermore, a brief online survey had been conducted in the UK,[11] which also restricted responses to worst-case. In the UK study, 153 ophthalmologists were surveyed with 35% reporting at least one patient with a macular injury associated with a handheld laser device. Several factors between the two surveys prevent a direct comparison, although both found injuries to occur overwhelmingly among males. A large portion of U.K. patients (53%) sustained moderate (20/50) or worse vision loss, compared to 16.7% in the current survey. The majority of injuries reported in the current study were considered minor/mild in nature (36.8%) based on the Snellen categories. Consistent with the present study findings, another U.K. study by Raoof et al.[12] reported that among the children who sustained retinal injuries as a result of handheld lasers (n = 16), the majority (75%) were also male. However, severity of injury was assessed differently focusing on the physical attributes of the retinal injury itself. Tests of visual acuity found 12.5% of the injuries were considered moderate and 17% severe using the logMAR scale. Although differences in methodology exist, these studies show that misuse of handheld lasers can lead to injury, which may result in some degree of vision loss.

In 2014, Health Canada generated questions for use in the rapid response component of the Canadian Community Health Survey (CCHS) to collect data on the use of, or exposure to, laser beam equipment among Canadians in the previous 12 months. Although the CCHS survey was not restricted to handheld laser devices, findings indicated that laser-induced injuries occurred most commonly from cosmetic treatments and from laser pointers used for entertainment (toy/game/light show).[13] The CCHS survey also found the vast majority of laser-induced eye injuries resulted from exposure by another person. This is consistent with the current survey findings where eye injuries predominately occurred as a result of exposure from another person, whether accidental (35.2%) or deliberate (32.4%) in comparison to self-inflicted (26.1%) (data not shown).

The current survey findings should be interpreted bearing in mind some important study limitations. One limitation involves the wording of the question used to estimate the number of injuries from handheld laser devices; in this question "resulting from a handheld laser. . ." was intended to exclude patients that presented with an eye injury/condition for some other reason. However, an evaluation of the open-ended comments found an inconsistency in 10 cases. In these cases, the respondents indicated that a patient presented with an eye injury resulting from a handheld laser device; however, their open-ended remarks indicated that the patient did not have an eye injury. This would have a minor impact on the number of injuries presented in Table 2 but would not affect results that are restricted to the most severe case as respondents are referring to a specific patient for these responses.

It is also acknowledged that some injury cases may have been reported by both an optometrist and ophthalmologist (e.g., double reporting). Although double reporting would have no impact on the frequency of injuries reported by the 2 professional associations, it would result in an overestimation of the combined prevalence rates. Slight changes to the questionnaire could identify referrals, offering some insight on the potential frequency of double reporting in surveys of this nature.

In this survey the reported response rates are worst-case estimates insofar as they are underestimated. Although the observed response rates are on par with or higher than reported elsewhere for similar surveys,[14–16] they do need to be considered when interpreting the data. A precise calculation of a survey response rate requires that the true denominator is known. Although the number of members for each society was known, there are numerous reasons why a member may have not received and (or) completed the survey. The reported response rate is underestimated because we have assumed that *all* members received the survey. Indeed, the CAO reported that only 58% of emails inviting participation to the survey were opened by its members (prevalence unknown for COS). Other factors that may have affected the response rate include, but are not necessarily limited to, the possibility that the society membership included retired members and (or) members that never received the email notification. Lower response rates are also to be expected where a restricted response period is imposed, and this is amplified when the response period coincides with summer holidays.

A descriptive summary of the open text comment boxes may provide some insight into the circumstances involving handheld laser-induced eye injuries. Among the notable remarks, there were several accounts of children "daring" one another to look directly into the laser beam. Other comments included descriptions of individuals directing handheld laser pointers at vehicle operators (ground or air) with a few accounts of workplace-related injuries. Some of these observations are consistent with other reports.[4,12,17]

The survey questionnaire included items designed to determine the device characteristics (classification, power output, laser beam colour) and where the devices were acquired. In the absence of any formal reporting system, which may prompt for such device details at the original point of treatment, it was not expected that health care professionals would have spontaneously sought to obtain this information from their patients upon treatment. The results confirmed our suspicions as this information was unknown by the vast majority of respondents (data not shown). Future research in this area should omit such questions and include others that further characterize eye injuries in order to clarify some of the uncertainties highlighted above.

As this was the first survey of this nature in Canada, some of the current limitations can be eliminated using improved survey terminology, while other shortcomings are inherent to the study design. Data collection was self-reported, which is subject to bias.[18] Recall bias is a concern even though it may be somewhat offset by restricting many of the responses to the most severe case. Although specific instructions were provided to all potential respondents to minimize bias, the extent to which reporting and (or) recall biases may have affected the response rate is unknown. This survey also experiences sampling bias in 2 important ways. On the one hand, the only means of data collection was through a questionnaire delivered to potential respondents through email or via a link in their association newsletter. Surveys of this nature are often ignored, flagged by email servers as "spam" email, and (or) undelivered to the intended recipient for a myriad of reasons. Future research in this area should consider additional means of data collection (e.g., mail surveys, telephone surveys) to improve response rate. Another sampling bias is related to the time period of data collection. Restricting data collection to summer months reduces the number of potential respondents as it conflicts with summer vacation.

Although this study was not intended to yield nationally representative data, the strength of this survey is that it provides new information on handheld laser-induced eye injuries reported by more than 900 ophthalmologist and optometrist specialists from across Canada. These respondents have first-hand professional experience in treating patients with these injuries, and this adds a high level of confidence to the findings. Collectively, the survey data provide additional information to support risk assessment and science-based decisions related to the management of risks to Canadians from handheld laser devices.

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:10.1016/j.jcjo.2019.02.001.

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Footnotes and Disclosure:

The authors have no proprietary or commercial interest in any materials discussed in this article.

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