Neurotrauma in Indigenous populations of Canada: challenges and future directions

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Abstract

Indigenous peoples of Canada are disproportionately affected by neurotrauma, which includes traumatic brain injury and traumatic spinal cord injury. Multiple factors, often grounded in the cultural assimilation and colonization of Indigenous peoples, contribute to the health disparities experienced by this population today. This review highlights key factors contributing to increased neurotrauma burden in Indigenous populations, with a focus on the social determinants of health. Specifically, issues pertaining to violence, substance abuse, and infrastructural challenges in Indigenous communities are discussed throughout this review. Additionally, current initiatives addressing neurotrauma burden are discussed in terms of prevention and treatment needs of Indigenous communities. The article concludes with comments on strategies to address issues of inequality and inequity which persist within Indigenous populations.

Introduction

Neurotrauma encompasses traumatic brain injuries (TBIs) and traumatic spinal cord injuries (TSCIs) which account for over 23 000 and 1700 hospitalizations annually in Canada, respectively.[1,2] The devastating impact of neurotrauma can profoundly affect a patient's quality of life, posing a significant financial burden to patients and the healthcare system due to the cost of acute care, rehabilitation, complications, and reduced post-injury employment prospects.[3,4] However, Indigenous populations in Canada are disproportionately affected by neurotrauma. Indigenous populations are culturally diverse, accounting for approximately 5% (1.6 million people) of Canada's population and include First Nations, Métis and Inuit peoples.[5] Compared to the rest of the Canadian population, these groups are 2.68, 2.05, and 1.84 times more likely to be hospitalized as a result of injury, respectively.[6,7] In addition to experiencing greater rates of TBI and TSCI, Indigenous populations in Canada experience higher rates of diabetes, asthma, and obesity compared to the rest of Canada.[8] Additionally, Indigenous populations in Canada are geographically diverse, with unique challenges faced by Indigenous peoples living in rural areas and on reserves. The disparities within these populations arise from many underlying social determinants of health that are deeply rooted in Canada's historical injustice towards Indigenous peoples.[9,10] This narrative review provides insight on the factors contributing to the increased neurotrauma burden in Indigenous populations of Canada, with a focus on the underlying social determinants of health. The discussion will conclude with comments on strategies to reduce the health disparity in the field of neurotrauma.

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Framework and methods

Narrative reviews provide an overview on a specific topic to inform readers on current research in the field. They contrast with systematic reviews, which involve a methodological approach to collecting and appraising research to answer a specific research question. The present narrative review reports key articles in the field of neurotrauma in Indigenous populations of Canada, and highlights key themes and concepts pertaining to this subject. The review uses information available from peer-reviewed journals through databases such as PubMed and Google Scholar, along with government websites as of December 2020. Additionally, the sources in this review use different terms to describe Indigenous peoples, including "Native" and "Aboriginal". Throughout the review, the term "Indigenous" is used for consistency and for its international recognition, although the government of Canada also uses the term "Aboriginal" to describe this population.[11] When studies or government programs refer to specific Indigenous groups, such as First Nations peoples, the name of the particular group is mentioned. Furthermore, this review utilizes an intersectionality framework to study the social determinants of health underlying neurotrauma in Indigenous populations. Additionally, both macro- and micro-level socioeconomic factors that impact health outcomes are considered in this review, in order to deeply assess the discrimination and prejudice faced by Indigenous populations.

Epidemiology of neurotrauma in the general Canadian population

Neurotrauma encompasses both TBI and TSCI. TBI refers to an impairment in normal brain function as a result of acute head trauma. Symptoms can be mild, moderate, or severe, ranging from transient changes in mental state to prolonged periods of unconsciousness and even death.[12] TSCI involves an acute mechanical injury to the spinal cord, often profoundly impairing patients' motor, sensory,

and autonomic functions.[1] In both forms of trauma, leading causes include unintentional falls and motor vehicle accidents.[13-17] Older adults are at an especially high risk of experiencing neurotrauma from unintentional falls.[13-17] Additionally, motor vehicle accidents and intentional injuries, such as assault and self-inflicted injury, are causes of neurotrauma most common in males aged 20-39.[13,14,16] In general, males are also more likely to experience neurotrauma across the lifespan compared to females.[13-15] Furthermore, a major cause of neurotrauma in children and adolescents is sports-related injuries, especially from ice hockey, football, and rugby.[13-15] Rural locations are also reported to have a greater prevalence of neurotrauma compared to urban regions.[14,18] Several other factors that compromise safety can increase the likelihood of neurotrauma occurring. These factors include playing sports without appropriate safety gear, driving under the influence or without a seatbelt, workplace and housing hazards that increase risk for falls, and violence in communities.[13,19,20] Engaging in risky behaviours and living or working in hazardous environments can explain why certain subgroups such as young males and construction workers are at a particularly high risk of neurotrauma.[13,19] In the case of minority populations, examining these factors in the context of historical injustice and existing inequalities can facilitate understanding of disparities in neurotrauma burden.

Epidemiology of neurotrauma in Indigenous populations of Canada

Indigenous populations are at increased risk of both TBI and TSCI and face challenges in accessing acute care and rehabilitation resources.[7,18,21,22] The following section explores the challenges individuals in Indigenous populations encounter in neurotrauma.

Substance Use and Violence

Alcohol and substance use are risk factors for TSCI and TBI as they contribute to behaviours that increase the risk of neurotrauma, such as violence, accidental falls, and motor vehicle accidents.[23] Additionally, substance use contributes to increased risk of in-hospital complications in the acute post-injury period and poorer rehabilitation outcomes in neurotrauma patients.[24] Blackmer and Marshall, 1999 investigated substance use and neurotrauma in Indigenous populations of Saskatchewan and found that Indigenous peoples admitted to Saskatoon City Hospital for TBI were more likely to have alcohol and drug involvement associated with their injury (83.3% vs. 9.6%, $p < 0.0001$).[21] Furthermore, a systematic review on motor vehicle crashes in Indigenous populations of Canada found three provincial studies reporting greater alcohol involvement in accidents involving Indigenous peoples versus non-Indigenous people.[25] These findings highlight the well-documented problem of alcohol and substance use among Indigenous peoples in Canada.[26] In fact, in the Aboriginal Peoples Survey, 73% of First Nations respondents listed alcohol consumption as a problem facing their communities.[27] Although alcohol was not consumed by Indigenous peoples prior to the fur trade, it had destructive consequences for communities once introduced by European settlers. Traditional healing practices, language, and cultural identity, which served to promote mental and physical well-being, were lost as a product of enforced assimilation, contributing to individuals turning to alcohol and drug use.[28] This is especially concerning for Indigenous youth, who are more likely to use drugs at an earlier age, and experience increased adverse events related to drug use, compared to non-Indigenous youth.[26]

Compared to the general population, studies on the etiology of neurotrauma in Indigenous populations document a greater proportion of injuries from assault, resulting partially from elevated rates of substance use.[29,30] In Quebec, Lasry et al., 2016 identified that members of rural health regions were more likely to suffer from TBI compared to the rest of the province.[18] Specifically, assault was a more frequent mechanism of TBI in rural Indigenous communities (Cree of Eeyou Istchee and Inuit) compared to rural non-Indigenous communities and the rest of Quebec (25.6% and 16.2% vs. 5.2% and 3.7% of TBIs). Additionally, a recent study by Ahmed et al., 2020, which involved patients admitted to hospital in Saskatoon, Saskatchewan for TSCI, reported that Indigenous patients constituted 34% of TSCI patients, despite making up approximately 16% of Saskatchewan's population.[7,31] Similar to TBI, the mechanism of injury for TSCI differs between Indigenous and non-Indigenous groups. TSCI in the non-Indigenous cohort occurred most often from transport and fall-related injuries, followed by sports-related injuries (39%, 37%, and 22%, respectively). The Indigenous cohort experienced TSCI primarily as a result of transportation, assaults, sports, and fall-related injuries (38%, 29%, 19%, 10%, respectively).[7] These results highlight the role of violence in neurotrauma in Indigenous populations, especially since the study had no non-Indigenous participants that suffered TSCIs from assaults. These findings are consistent with other research studies reporting higher rates of assault in Indigenous populations compared to the rest of Canada.[29,30,32] Although in the general population, 20-39-year-old males are at a particularly high risk of neurotrauma from assaults, additional groups in Indigenous populations are at higher risk.[13] This includes Indigenous women, who are approximately four times more likely to experience abuse than non-Indigenous women, and Indigenous children, who are more likely to experience childhood maltreatment.[29,30,33] The underlying reasons for high rates of assault in this population are complex, involving several issues aside from substance use, including lower educational attainment, and higher rates of unemployment and mental health problems.[29,34] These issues are often deeply rooted in the trauma endured by Indigenous peoples during the course of Canadian history.[28] For example, the Indian residential school system has posed significant and ongoing intergenerational effects on the mental health of Indigenous families, contributing to higher rates of child abuse, depressive symptoms, and suicidal thoughts.[35-37] In the past, the Canadian government was actively involved in the marginalization of Indigenous peoples, not only through the enactment of residential schools, but also by enforcing policies that negatively impacted Indigenous socioeconomic conditions, culture, traditional healing practices, and access to healthcare services.[28] Therefore, elevated rates of TBI and TSCI in Indigenous communities need to be studied by looking beyond proximate causes of alcohol consumption and drug use, by assessing the upstream factors that contribute to violence.

Infrastructure disparities in rural Indigenous communities and reserves

Although a significant portion of Indigenous peoples in Canada live in urban locations, approximately 60% live in rural locations, compared to 27% of the general population.[38] Considering the fact that Indigenous peoples are more likely to experience neurotrauma in rural locations compared to the general population, geographic considerations are crucial in understanding the increased

neurotrauma burden.[21] For example, rural locations may have infrastructural issues that increase the risk of TSCI and TBI. In many reservation-based rural communities, the lack of paved roads encourages the use of all-terrain vehicles and snowmobiles, which carry a greater risk of neurotrauma for both drivers and passengers following accidents.[39] There are also additional driving risks associated with roads on reserves, such as poor road conditions, increased alcohol consumption and drug use while driving, and reduced use of seatbelts.[40] Additionally, the different driving conditions on reserves impact the severity of motor vehicle accidents. Desapriya et al., 2011 compared motor vehicle crashes in Saskatchewan on and off reserves and found on-reserve crashes were more likely to involve multiple collisions and lead to more severe injuries than those off-reserve.[40] Other community factors, including dilapidated housing conditions and employment in hazardous lines of work without proper safety equipment, increases the risk of falls that can contribute to neurotrauma.[41] The lack of adequate road infrastructure and housing does indeed increase the risk of neurotrauma, but also highlights a broader problem with infrastructure on reserves and rural Indigenous communities that applies to wastewater, education, and cultural and recreational facilities.

Access to care and rehabilitation

Indigenous peoples are not only more likely to experience neurotrauma, but also face disparities in treatment and rehabilitation. In a study based in Saskatchewan, Indigenous patients with TBI were more likely to have a surgical procedure (55.6% vs. 23.1%, $p = 0.0102$), less likely to have family conferences to discuss patient care (1.04 vs. 0.33, $p < 0.0001$), and less likely to receive post-discharge support (90.4% vs. 33.3%, $p = 0.0052$), compared to non-Indigenous patients with TBI.[21] This study highlights key differences in patient experience despite similar injury severity for both groups (no significant difference in initial Glasgow coma scale score or duration of post-traumatic amnesia). Although not statistically significant, Ahmed et al., 2020, also identified disparities in access to care in the context of TSCI. Indigenous peoples were found to have a longer period from the time of injury to acute care (8.0 h vs. 7.0 h, $p = 0.38$) and a longer duration from admission to surgery (20.0 h vs. 15.0 h, $p=0.20$), despite Indigenous cohorts having fewer comorbidities that would delay surgical treatment.[7] The increased time to acute care is likely a result of Indigenous peoples experiencing injury in more rural locations, but the disparity in time to surgery is especially concerning as early surgery is recommended in some cases of TSCI.[21,38,42]

Research on the experiences of healthcare providers and Indigenous patients with neurotrauma helps further elucidate key issues contributing to disparities. This includes a lack of rehabilitation services on reserves and rural communities, often because rehabilitation systems favor the movement of patients from remote areas to specialized urban centers.[43] Consequently, Indigenous patients may need to travel long distances to access care in locations where they lack the familial support available in their own community.[44,45] The added challenge of language barriers, cultural adjustments, and impaired cognitive ability in the case of TBI, makes relocating to urban centers especially difficult for Indigenous patients from rural communities.[43] This is particularly concerning as approximately 60% of Indigenous populations in Canada live in rural areas.[38] Furthermore, Indigenous patients with concurrent neuropsychiatric conditions, such as drug and alcohol addictions, struggle to be admitted into rehabilitation programs following neurotrauma. This is often because of a lack of practitioner training and the concern of concurrent psychiatric conditions interfering with therapy.[43] This presents a significant barrier to rehabilitation, considering the elevated rates of substance abuse and other mental health conditions, such as mood and behaviour disorders in this population, particularly for those with parents or grandparents who attended residential schools.[34, 43]

While there are concerns with receiving care in specialized urban centers, there are also issues for Indigenous patients returning back to their communities. Ahmed et al., 2020 demonstrated that the time from hospital admission to discharge to the community for patients with TSCI was significantly longer for Indigenous peoples than non-Indigenous peoples (104.0 days vs. 34.0 days, $p = 0.016$).[7] This is despite both groups having similar injury severity and more notably, the Indigenous group consisting of younger patients with fewer comorbidities. Such differences in patient experience may stem from the disparity in community resources for Indigenous communities, especially in remote areas and reserves.[43,44] For example, Wearmouth and Wielandt, 2009 studied accessibility issues on reserves for patients in wheelchair post-TSCI.[46] These issues include poor reserve terrain, which makes mobilization for those in wheelchairs particularly difficult, especially during winter months. Other infrastructural problems, such as a lack of sidewalks or curb cuts in existing sidewalks, present additional challenges to wheelchair accessibility. Home assessments are another component in improving quality of life for patients with disability who suffered from neurotrauma.[47] However, they can be difficult to arrange due to the rural location of many Indigenous communities. Disagreements between federal and provincial governments on community service coverage for Indigenous peoples adds another barrier to accessing rehabilitation and accessibility services in their communities.[48] These issues not only serve as an impediment to discharging patients back into their community but make the recovery period even more difficult by limiting patients' ability to regain independence and engage in community activities such as cultural ceremonies.[46,49]

Additionally, Indigenous patients with neurotrauma and their providers report a lack of cultural sensitivity in the healthcare system, commenting on the need for increased translational services, culturally appropriate assessments of cognitive function, and integration of traditional healing methods in practice.[43,44] This presents an important consideration, as the lack of cultural competence may contribute to poorer functional outcomes post-injury, which in turn may perpetuate inequality by impairing the ability of Indigenous patients to return back to work and regain independence.[50, 51] The importance of this is highlighted in a review by Niemeier and Arango-Lasprilla, 2007 demonstrating that minority status is not only a risk factor for TBI, but is associated with reduced provision of services throughout the entire recovery period.[52] Although socioeconomic, geographical, and historical factors interplay in altered neurotrauma care for Indigenous populations, the role of discrimination in the healthcare system should also be recognized. Recent studies document discriminatory attitudes and behaviours among healthcare professionals that negatively impact the care Indigenous populations receive in Canada.[53,54] The disparities in care Indigenous peoples receive following neurotrauma are a reminder of the institutional discrimination that remains from over a hundred years of systemic racism from both the Canadian government and broader Canadian society.

Current initiatives towards reducing neurotrauma burden in Indigenous populations

The following section provides examples of current efforts to address the factors contributing to increased neurotrauma burden in Indigenous populations, focusing on prevention and treatment strategies.

Prevention

Government programs

Indigenous Services Canada, a department of the Government of Canada, is responsible for ensuring the delivery of high-quality services to Indigenous peoples and their communities. The department provides programs that address risk factors for neurotrauma such as domestic abuse through the Family Violence Prevention Program, substance use through the National Native Alcohol and Drug Abuse Program, and infrastructure through the First Nation On-Reserve Housing Program.[55] Furthermore, government reports have served to guide further initiatives by identifying particular subgroups of the Indigenous population in need of additional support. For instance, in 2020, the Final Report of the National Inquiry of Missing and Murdered Indigenous Women and Girls prompted additional investments into community-based violence prevention projects for Métis women, girls, LGBTQ, and Two-Spirit Indigenous people.[56] The programs and funding provided by the Canadian government address many of the risk factors for increased neurotrauma burden in Indigenous populations, however, much of this risk is largely attributable to the impact of colonization, intergenerational trauma, and the damage to Indigenous culture and way of life throughout Canadian history. The Canadian government's mandate towards advancing reconciliation with Indigenous peoples hopes to enable these populations to reclaim their culture, self-governance, and traditional way of life, acknowledge the trauma inflicted by past governments through residential schools, and educate the general Canadian public on Indigenous history and culture to combat racism and discrimination. For example, the Nation Rebuilding Program is a project initiated in 2018 that assists Indigenous peoples in re-developing their communities and governments to address their unique needs in concordance with their own principles and beliefs.[57] Although there are several programs available to address the needs of Indigenous communities, they require substantial advocacy by Indigenous leaders and organizations to be implemented. Continued advocacy and accountability of governments is therefore necessary to continue working towards equity and justice for Indigenous peoples.

Institutional efforts

Research and healthcare institutions across Canada have also implemented strategies to address the burden of neurotrauma in Indigenous populations. For example, in 2016, the Canadian Institute of Health Research (CIHR), a major research funding agency in Canada, listed the health and wellness of Indigenous peoples as one of its four priorities of research.[58] The commitment involves an action plan containing 10 items to improve the quality and quantity of Indigenous health research through increased investments and collaboration between the CIHR and Indigenous communities. In particular, programs such as the Indigenous Healthy Life Trajectories Initiative and Pathways to Health Equity for Aboriginal Peoples program, serve to better understand the underlying social determinants of health across the lifespan, providing valuable data to develop programs that protect against neurotrauma.[59, 60]

Community-based efforts

There are also community-based interventions that help reduce the risk of neurotrauma in Indigenous populations by addressing underlying risk factors. The interventions include substance use and violence prevention programs.[61-63] The advantage of hosting these programs at the community level is that they facilitate the integration of traditional healing practices by involving community members and acknowledge the unique challenges Indigenous peoples face from historical trauma.[36,63] Community-based programs also address the barriers to accessing substance use and violence prevention programs that are held at sites distant from Indigenous communities, especially those on reserves. This includes having to take time off work, being away from family, and the fear of receiving treatment in unfamiliar environments.[63] Furthermore, having family and friends close by during the intervention process provides participants with a support system they would not have at more distant sites.[64] There is a substantial amount of level II and level III evidence for the benefits of community-based programs in reducing the behaviours that increase risk of neurotrauma.[63] For example, Puchala et al., 2010 described the use of traditional healing elders in cases of domestic violence in Indigenous communities, finding statistically significant changes in characteristics of domestic abuse following the intervention.[62] Other interventions involving Indigenous treatment providers, traditional healing practices, and holistic family and community approaches also demonstrate evidence of being effective.[63]

Treatment

Initiatives are also being implemented to improve the treatment Indigenous peoples receive following neurotrauma. Educational institutions and healthcare providers are increasingly recognizing the importance of cultural competency and safety in reducing disparities between Indigenous and non-Indigenous peoples. For example, educational programs for doctors, nurses, and other allied health professionals are incorporating Indigenous health into their curriculums.[65] Furthermore, research groups are publishing recommendations and guidelines based on the experiences of Indigenous peoples in healthcare.[66-68] Reviews of interventions implemented by healthcare institutions are also valuable in identifying key themes and designing frameworks to improve Indigenous peoples' experience in Canada's healthcare system.[69] For instance, a review by Brooks-Cleator et al. 2016, identified culturally safe health initiatives for Indigenous peoples across Canada and found 6 main themes: collaboration/partnerships, power sharing, addressing the broader context of the patient's life, a safe environment, organizational and individual level self-reflection, and training for healthcare providers.[70] A better understanding of the principles of cultural safety in healthcare delivery for Indigenous peoples is critical in transitioning from theory to widespread practice. In Ontario, several hospitals have added full-time Indigenous Patient Navigators, guidelines for smudging ceremonies, and Indigenous advisory councils to help staff provide services to Indigenous peoples.[71] Additionally, telemedicine is being used to address the challenges rural communities and reserves face in access to neurotrauma care. For example, pediatric concussion telemedicine programs have been developed to provide specialized neurological

care to rural areas.[72,73] Telerehabilitation is also being utilized to improve post-injury outcomes following neurotrauma.[74,75] Despite the technological advances enabling services to be provided virtually, access to a trauma center immediately following injury still remains a significant challenge due to distance from rural communities.[76]

Future directions

Overall, there are several factors that contribute to increased neurotrauma burden in Indigenous populations, which often result from the destructive effects of colonization and cultural assimilation.[23,28,32,39] Highlighted in the remainder of this review are broad considerations when addressing issues of inequality and inequity which persist in Indigenous populations.

Improving research quality and quantity

There is a lack of research pertaining to the health needs of Indigenous populations in Canada.[77] A review by Zeiler and Zeiler, 2017 identified only 10 manuscripts discussing social determinants of health and TBI in North American Indigenous populations, only 2 of which were in the Canadian context.[78] One factor underlying this issue is the lack of high-quality health data available for performing meaningful and impactful research.[79] Smylie and Firestone, 2015 identified two fundamental concerns in Indigenous health research: the lack of Indigenous identifiers in Canada's health datasets, and the lack of meaningful research partnerships with Indigenous communities.[79] The historical dehumanization of Indigenous peoples in health research poses challenges to forming strong research partnerships, however this collaboration is critical in designing relevant health interventions that meet the needs of Indigenous communities.[80] Furthermore, Indigenous peoples have been excluded from national health studies in the past, such as the Canadian Community Health Survey, the Canadian Maternity Experiences Survey, and the National Longitudinal Child and Youth Survey.[81-83] This contributes to gaps in knowledge that create barriers to implementing evidence-based health interventions within Indigenous communities. Therefore, governments, research institutes, and healthcare professionals must work towards partnering with members of Indigenous communities to build health databases that provide high-quality data on the well-being of Indigenous peoples. These efforts will help encourage further research in the field of Indigenous health, leading to a better understanding of the unique challenges faced by Indigenous communities. In the field of neurotrauma, further research is important as more data is needed on the burden faced by specific subgroups of Indigenous populations, such as those belonging to other minority groups based on race, sex, or religion. Incorporating disaggregated data into databases is critical in obtaining this information and allocating resources to the most disadvantaged members of Indigenous populations. Additionally, data on neurotrauma for Indigenous populations in the Territories and Atlantic provinces of Canada is particularly scarce. Obtaining a more comprehensive view of neurotrauma across the Canadian landscape can prove valuable in recognizing which provinces fare better than others, potentially leading to investigations on why this may be the case. Furthermore, additional data can be used to examine if Indigenous peoples are more likely to experience a dual diagnosis of TBI and TSCI compared to the general population and also be used to gather more level I evidence for the benefits of community-based interventions. Increasing research efforts can contribute to the development of health programs that reduce the disproportionate incidence of neurotrauma and other medical conditions in Indigenous populations.

Addressing safety concerns in Indigenous communities

Compared to the rest of the Canadian population, Indigenous peoples are more likely to experience neurotrauma as a result of assault and motor vehicle accidents.[7,18,40] In both cases, increased alcohol and substance abuse appear to play a contributory role.[21,23] Substance abuse is a complex problem requiring multifaceted solutions that are considerate of Indigenous culture.[63] This includes community-based addiction programs which address substance abuse at the community level, in order to develop interventions that are relevant to members of specific communities.[63] Efforts to reduce violence in certain Indigenous communities have also been attempted, including using traditional spirituality, night patrols, and shelters for those fearing domestic abuse.[61,62] Addressing the higher rates of violence in Indigenous communities is especially challenging as the underlying problems are vast and interrelated, including low educational attainment, high unemployment rates, and high rates of mental health problems, largely attributable to intergenerational trauma.[29,34-37] In addition to addressing substance abuse and violence, the incidence of neurotrauma can be reduced by tackling infrastructure problems in certain Indigenous communities. Issues concerning infrastructure are implicated in the higher rates of motor vehicle accidents on reserves, difficulties for patients recovering post-injury, and may contribute to increased fall risk in this population.[40,41,46] Implementing programs to resurface roads, improve signage, and enhance visibility at intersections, particularly on reserves, can make a meaningful impact on the driving safety of communities.[84] Implementing strategies to address low seat belt use, speeding, and driving under the influence are also important in reducing risky driving practices.[40,85] In effect, this can be achieved through several types of interventions, such as educational programs, that promote a culture of road safety and knowledge of the risks of impaired driving.[85] Addressing substandard and overcrowded housing in Indigenous communities is also critical in reducing the risk of falls.[41,86] Overall, these issues are complex, dynamic, and intertwined as they are rooted in centuries of injustice and discrimination towards Indigenous peoples. Therefore, it is essential to consult and collaborate with Indigenous community members, policy makers, and health experts to identify appropriate ways to approach these pressing concerns.

Improving infrastructure for rehabilitation and care in Indigenous communities

Following neurotrauma, it is important to have an accessible home and community that promotes patients' independence and improves quality of life. In certain Indigenous communities, particularly those on reserves, patients with disability following neurotrauma find their communities lack accessible infrastructure, such as sidewalks and curb cuts in existing sidewalks.[46] Investments in infrastructure are therefore needed to enable those affected by neurotrauma to participate in community activities and gradually regain independence. Additionally, funding disputes for home assessments and the rural location of many Indigenous communities act as barriers to getting homes modified for injured or recovering

patients. Financial disagreements between provincial and federal governments resulted in Jordan's Principle for pediatric Indigenous patients, which serves to ensure timely access to medical care. However, this principle is followed inconsistently and does not address the challenges of the adult Indigenous population recovering following neurotrauma.[48] Moving forward, it is important for governments to continue working with Indigenous leaders to improve infrastructure in their communities. The Canadian Council for Public-Private Partnerships estimates that approximately $30 billion in investment will be needed to address the Indigenous infrastructure gap.[87] This investment will not only help reduce neurotrauma burden by developing safer roads and homes but will also enable communities to develop rehabilitation facilities and more accessible infrastructure for patients post-injury. More broadly, infrastructure projects that address basic needs, such as water quality and solid waste management on reserves can have a substantial impact on health and well-being.[88]

Applying culturally relevant care

The present review describes the lack of culturally sensitive care in the rehabilitation of Indigenous patients with neurotrauma.[43, 44] However, certain recommendations have been made to improve the current state of the healthcare system. This includes raising awareness of Indigenous cultural beliefs, addressing language barriers, recognizing personal biases, and discharge considerations for those living in rural communities and reserves.[52] Several interventions have already been attempted to improve cultural competency among healthcare professionals and the Canadian healthcare system at large.[69,89] Additionally, there has been an increased focus in integrating cultural competency and cultural safety in the training of future healthcare professionals, although more work is needed to successfully implement this within educational programs.[65] Unfortunately, the lack of research evaluating the effectiveness of cultural interventions in the Canadian context makes it particularly difficult to improve educational programs over time.[90] As healthcare professionals in Canada recognize a gap in knowledge of Indigenous health and the role of social determinants of health, it is imperative to invest in education to ensure health care professionals provide culturally competent and personalized care to Indigenous patients.[91,92] In addition to training healthcare providers, institutional changes are necessary to reinforce and promote principles of cultural safety in all major aspects of the healthcare system.[70,93] Ultimately, a more equitable healthcare system for Indigenous peoples will involve collaboration among organizations, governments, and research and education institutions, along with consultation with patients and other stakeholders in the system.

Conclusion

This review highlights key challenges facing Indigenous populations of Canada in the field of neurotrauma. Overall, the actions of previous governments and racism within Canadian society continue to have a devastating impact on Indigenous communities today. The abduction of Indigenous children to residential schools and the prohibition of Indigenous cultural practices has led to intergenerational trauma that continues to have direct and indirect impacts on health.[28,35-37] Issues such as violence, alcohol and drug abuse, infrastructural problems, and road safety in Indigenous communities are often deeply rooted in a historical context. The multi-billion dollar infrastructure gap demonstrates challenges in meeting basic needs, such as safe drinking water, in certain Indigenous communities.[87] In addition to disparities in health, Indigenous populations face a disproportionate burden of unemployment, poverty, food insecurity, and have lower rates of high school graduation.[94] Although the Canadian government is collaborating with Indigenous partners to work towards reconciliation, efforts must continue to overcome the damage inflicted on Indigenous communities in the past.[95] A combination of interventions from public and private agencies, along with advocacy from the general public, is necessary to move towards a more equitable Canada.

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