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Challenges Identified, and Solutions Offered, for Fire Service in Rural And Cold Climate Contexts: A Scoping Review

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Challenges Identified, and Solutions Offered, For Fire Service in Rural and Cold Climate Contexts: A Scoping Review

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Abstract

Rural, cold climate communities, such as those in coastal and northern Newfoundland and Labrador, face documented challenges pertaining to financial and infrastructure constraints and changing personnel considerations. Fire service delivery must adapt to these realities. The aim of this paper is to understand the scope of the scholarly and grey literature addressing challenges and solutions for fire service delivery and firefighting in rural and cold climate contexts, particularly as they pertain to Newfoundland and Labrador, Canada. The review was conducted using an academic search engine, topic-specific search engines, grey literature databases, and a review of relevant websites to produce information sources. Peer-reviewed articles, professional reports, theses and dissertations, and other article types indicated several challenges and solutions. The challenges identified were represented in scholarly and grey literature. These included challenges related to resources, the environment, firefighting tasks, and community. Likewise, solutions centred around resources, firefighting tasks, and community were represented in both scholarly and grey literature. Specific identification of future research needs was limited in the research reviewed. Further investigation and evaluation of the efficacy of solutions for specific cold climate, rural regions are advised.

Keywords: fire service, firefighting, rural, cold climate

Défis identifiés et solutions proposées, pour les services d'incendie dans les contextes ruraux et de climat froid : un examen de la portée

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Résumé

Les communautés rurales à climat froid, comme celles de la côte et du nord de Terre-Neuve-et-Labrador, font face à des défis documentés liés aux contraintes financières et d'infrastructure et aux changements de personnel. La prestation des services d'incendie doit s'adapter à ces réalités. Le but de cet article est de comprendre la portée de la littérature scientifique et de la littérature grise traitant des défis et des solutions pour la prestation des services d'incendie et de lutte contre les incendies dans les contextes ruraux et de climat froid, en particulier en ce qui concerne Terre-Neuve-et-Labrador, au Canada. L'examen a été effectué à l'aide d'un moteur de recherche universitaire, de moteurs de recherche thématiques, de bases de données de littérature grise et d'un examen des sites Web pertinents pour produire des sources d'information. Des articles évalués par des pairs, des rapports professionnels, des thèses et mémoires et d'autres types d'articles ont indiqué plusieurs défis et solutions. Les défis identifiés étaient représentés dans les littératures savante et grise. Ceux-ci comprenaient des défis liés aux ressources, à l'environnement, aux tâches de lutte contre les incendies et à la communauté. De même, les solutions centrées sur les ressources, les tâches de lutte contre les incendies et la communauté étaient représentées à la fois dans la littérature savante et grise. L'identification précise des futurs besoins de recherche était limitée dans les recherches examinées. Une enquête et une évaluation plus approfondies de l'efficacité des solutions pour des régions rurales à climat froid spécifique sont conseillées.

Mots clés: service d'incendie, lutte contre les incendies, rural, climat froid

1.0 Introduction and Scholarly Context

1.1 Rationale

Rural communities face challenges in the delivery of services due to declining and aging populations. Specific challenges pertain to infrastructure and financial constraints as well as retention and recruitment of career and volunteer personnel (e.g., in Newfoundland and Labrador; Curran, 2018). These specific concerns are mirrored in rural volunteer emergency services in general (e.g., Miller & deVries, 2015) and in volunteer fire services in Canada (e.g., Colibaba et al., 2021). This review was conducted with a wide scope which included challenges and solutions for both career and volunteer rural and cold climate fire service delivery throughout the world. While firefighting is considered one of the most dangerous jobs in the world, (DeJoy et al., 2017), firefighters' experiences vary based on the context and geographical area where they perform their duties (Colibaba et al., 2021).

It is unclear what types of information, specifically around challenges and solutions for rural and cold climate contexts, are available in the peer-reviewed and grey literature. Because of this, a scoping review was conducted to map research and other sources of information available regarding rural and cold climate fire service delivery and firefighting. This type of review can be used for clarification of complex topics, with emerging evidence, and for refining future research questions (Levac et al., 2010).

1.2 Objectives

We examined the scholarly and grey literature to:

- identify what information is available about challenges in fire service delivery pertaining to cold climate, and rural communities;
- identify what information is available about possible solutions and approaches to identified challenges; and
- identify recommended future research.

1.3 Outline

This paper begins with a description of the methods used to obtain and evaluate scholarly and grey literature for inclusion in the synthesis of results. Next, the results are presented in chart and synthesis formats. A discussion of the key challenges identified, and possible solutions offered by the literature specific to cold climate and rural locations, is provided, followed by a discussion of future research needs. The conclusions highlight similarities in challenges and solutions identified across the types of literature reviewed.

2.0 Methods

2.1 Eligibility Criteria

Published articles which addressed challenges and/or solutions for firefighting or fire service in author-defined cold climates, rural areas, or a combination of these were eligible for inclusion in this review. Peer-reviewed journal articles, published in English and available in full text prior to March 2021 (published between January

1, 2000, and March 1, 2021) were eligible for inclusion. Other papers, including theses and dissertations, research and committee reports, government reports, conference papers, and trade magazine articles, addressing the same topics and timeframe, were also eligible for inclusion in this review and were charted separately. The rationale for including a broad range of sources over several years is to gather information from many stakeholders in this applied research domain, while the rationale for limiting the publication timeframe is that best practices in firefighting evolve over time and standards, such as those issued by the National Fire Protection Association (NFPA), are updated every three to five years (“How the NFPA Standards Development Process Works”, n.d.). Charting the types of sources separately allows for separate consideration of validity, risk of bias, and relevance when using the information to inform decision-making.

2.2 Search Plan

The search plan was developed to incorporate four different types of information sources: (1) Google Scholar search engine, (2) grey literature databases, (3) topic-specific Google search engines, and (4) targeted websites. These strategies were adapted from both Tricco et al. (2018) and Godin et al. (2015).

Google Scholar was used because it enables full-text search and provides access to many articles, reports, theses, and conference papers, and because it is a recommended tool for systematic reviews (Gehanno et al., 2013). The additional information sources for searching the grey literature were The Networked Digital Library of Theses and Dissertations (NDLTD) and Open Grey, a system for information on grey literature in Europe.

Custom Google search engines for firefighting issues and resources were used to search for additional documents. Fire ReSearch Engine was developed by The International Association for Fire Safety to consolidate and search many relevant fire science publication databases. The National Institute of Standards and Technology created a search engine titled FireDoc. FireDoc provides an online bibliographic database that contains a large collection of building and fire research materials from many sources. The search for each key term was either completed at 100 pages or earlier when the results were no longer relevant from reviewing the title and short text underneath.

Browsing of targeted websites of relevant firefighting organizations and agencies was conducted using Google to locate organizations publishing on cold climate firefighting and rural firefighting. This step included a Google search to identify relevant and useful organizations and websites. Following this search, each of the relevant websites’ homepages was searched for potentially relevant documents. Each website and the date on which the search was conducted were documented in Excel. Some websites, such as The Firehouse, Firewell, and Firefighting in Canada, did not have a search bar, so each piece of literature was searched individually.

2.3 Search

The following Search terms were used individually and in combination: “Newfoundland”, “Labrador”, “firefighting”, “rural”, “dispersed location”, “cold climate”, “community risk”, “fire service”, “aging firefighters”, “car fires”, “tunnel fires”, “small population”, “key challenges”, “regionalization”, “kitchen fires” and “indigenous”. The first eight search terms were developed alongside the aims of the

study, while the last eight terms were added after an initial search of literature specific to Newfoundland and Labrador revealed them as relevant to the study aims.

2.4 Document Selection

Once all search strategies were completed, the selection process involved evaluating the literature through two exclusion phases. The first exclusion phase involved NP examining the abstracts, and, if necessary, the introduction of documents to ensure that they were written in English and were not duplicates of already-included documents. The second exclusion phase involved a thorough assessment of the full text to determine if it met the remaining inclusion (eligibility) criteria. Both NP and ES completed this phase independently, with ES resolving any discrepancies through a second review of the document in question.

2.5 Data Charting Process, Data Items, and Synthesis of Results

From the included documents, the author(s) and date of publication, the location (if applicable to the work), and whether the work addressed rural and/or cold climate issues in firefighting or fire service were recorded. Any challenges and/or solutions presented in the document were summarized by ES and recorded in point form in the charts. Specific mentions of future research needs were also recorded. Separate charts were created for peer-reviewed articles, reports, theses and dissertations, and other types of documents.

2.6 Limitations

Scoping reviews are designed to capture the breadth of information available on specific topics, in this case, challenges and solutions in rural and cold climate firefighting. This review did not formally assess the information sources for quality, validity, or reliability of research design or the information provided, as would be typical of a systematic review. Time and resource limitations put on the search strategy may have affected the total number of information sources obtained in this scoping review.

3.0 Results

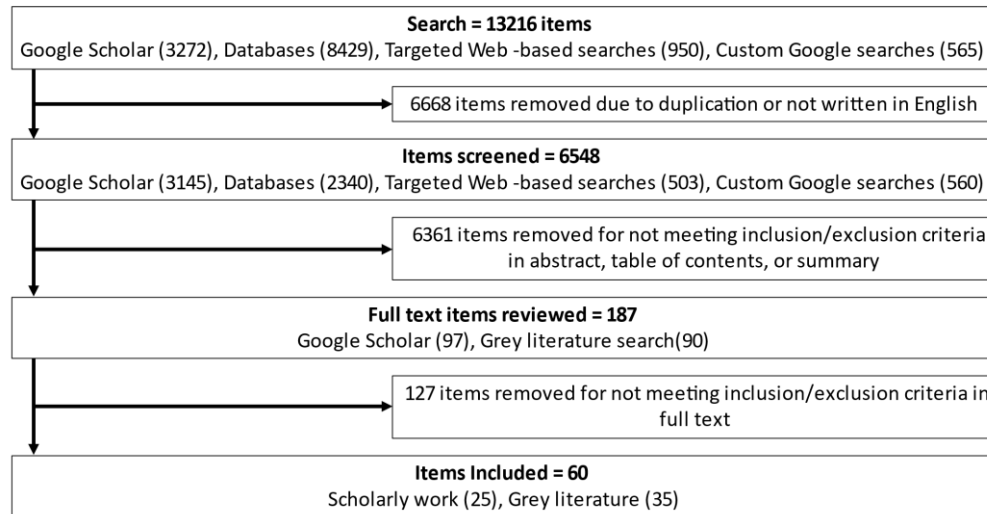
3.1 Selection of Sources

A total of 60 items, 25 scholarly works (peer-reviewed and theses/dissertations) and 35 from the grey literature, were included in the review of 13216 items identified in the initial search strategy. Adopting the format of Williams et al. (2013), Figure 1 outlines the selection process for the sources of evidence included in our review.

3.2 Characteristics and Results of Sources of Evidence

Consistent with the objectives of this review, we recorded the author(s) and date of publication, the location addressed, whether the item dealt with rural communities, cold climates, or both, and a summary of the challenges and/or proposed solutions presented within the document. Documents were labeled as scholarly literature (peer-reviewed articles, theses or dissertations) or grey literature (reports, other documents). Tables 1 and 2 summarize the challenges and solutions from the sources of evidence.

Figure 1: Selection process for sources of evidence.



3.3 Synthesis of Results

Twenty-five scholarly works (14 peer-reviewed articles and 11 theses and dissertations) provided challenges (see Table 1) and solutions (see Table 2) for firefighting and fire service. Sixteen of these provided information regarding rural challenges and solutions, four provided information regarding cold challenges and solutions, and five provided information regarding both rural and cold challenges and solutions. Five papers addressed issues in Canada, six in United States, three in Norway, one of each in the United Kingdom, China, South Africa, Antarctica, and Australia. Two addressed multiple locations (Australia, Canada, United States; United States, Canada, Norway), and two described the locations as arctic, subarctic, and harsh environments, and arctic, sub-arctic offshore operations. Two did not address specific locations.

Thirty-five documents from the grey literature (18 reports, 12 trade magazine articles, 3 newspaper articles, 1 book chapter, 1 educational course booklet and 1 insurance company webpage article) provided challenges (see Table 1) and solutions (see Table 2) to firefighting and fire service. Twenty of these provided information regarding rural challenges and solutions, eleven provided information regarding cold challenges and solutions, and four provided information regarding both rural and cold challenges and solutions. Eleven sources addressed issues in Canada, seventeen in the United States and one addressed North America. Two sources addressed issues in New Zealand and one each in Finland, Norway, Greenland, Iceland, and Russia.

Table 1. *Challenges*

Resources	
(44 references; 22 scholarly, 22 grey literature)	
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Budgetary and other financial constraints	Arnold, 2015; Brooks et al., 2020; Bryant, 2020; Catino, 2015; Curran, 2018; Fang et al., 2018; Feng et al., 2016; Halonen & Hellenberg, 2006; Hughes, 2018; Preston, 2004; Rutherford, 2008; Tymstra et al., 2020; Wainwright & Dhaliwal, 2013
Need for new/updated equipment	Bryant, 2020; Catchpole, 2000; Fang et al., 2018; Forsgren Associates Inc., 2005; Geiman & Gottuk, 2006; Keller, 2013; LaFemina, 2019; Log, 2018; Myburgh, 2012; O’Neal, 2017; Stalker & Phyne, 2014
Human resource issues including recruitment, leadership, and administration	Arnold, 2015; Brooks et al., 2020; Bryant, 2020; Catino, 2015; Clare & Kelly, 2017; Cote et al., 2014; Fang et al., 2018; FEMA, 2007; Frangione, 2021; Halonen & Hellenberg, 2006; Hughes, 2018; Hutchins, 2010; Kennedy, 2018; Khan et al., 2015; Magoteaux, 2016; Metallinou & Log, 2017; O’Neal, 2017; Preston, 2004; Rutherford, 2018; Stalker & Phyne, 2014
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Environment	
(39 references; 19 scholarly, 20 grey literature)	
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Snow and/or ice at fire or training location	Brouwer, 2007; “Important Safety Tips for Winter Firefighting”, 2018; Keller, 2013; Khan et al., 2015; Metallinou & Log, 2017; Pindelski, 2011
Freezing equipment	Fortune, 2005; Khan et al., 2015; Metallinou & Log, 2017; “The Surprising Risks of Cold-Weather Firefighting”, 2019; Rahman et al., 2019
Extreme cold/wind	Alexander et al., 2013; Cain, 2019; Fang et al., 2018; “Be prepared for Cold-Weather Firefighting”, 2009; Khan et al., 2015; Log, 2016; Metallinou & Log, 2017;2018; Pindelski, 2011;” The Surprising Risks of Cold-Weather Firefighting”, 2019; Vaughn, 2020
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Table 1 continued

Land/resource use	Hamins et al., 2012; Hirsch & Fuglem, 2006; Kennedy, 2018; Klein, 2017; Metallinou & Log, 2017, 2018; Parson et al., 2001; Preston, 2004; Rutherford, 2018; Tymstra et al., 2020
Water supply and access	Davis, 2000; Keller, 2013; LaFemina, 2019; Magoteaux, 2016; Moritz & Butsic, 2020; Myburgh, 2012; Zehnder, 2017

Firefighting tasks

(31 references; 14 scholarly, 17 grey literature)

Training challenges including increased expectations and cost	Arnold, 2015; Bryant, 2020; Catino, 2015; Cote et al., 2014; Fang et al., 2018; FEMA, 2007; Frangione, 2021; O’Neal ,2017; Preston, 2004; Stalker & Phyne, 2014; Wainwright & Dhaliwal, 2013
Physical and psychological risks to firefighters	Eltz, 2015; “Be Prepared for Cold-Weather Firefighting”, 2009; Fortune, 2005; Hutchins, 2010; Halonen & Hellenberg, 2006; Hamins et al., 2012; Keller, 2013; Khan et al., 2015; LaFemina, 2019; Metallinou & Log, 2017; “The Surprising Risks of Cold-Weather Firefighting”, 2019; Scott, 2017
Expanding job description and expectations	Arnold, 2015; Catino, 2015; Cote et al., 2014; Fang et al., 2018; FEMA, 2007; Halonen & Hellenberg, 2006; Preston, 2004; Stalker & Phyne, 2014

Community

(21 references; 9 scholarly, 12 grey literature)

Lack of working with Indigenous communities/land managers	Christianson, 2015; Oberndorfer, 2020
Aging community	Clare & Kelly, 2017; Cote et al., 2014; Fang et al., 2018; FEMA, 2007, 2019; Geiman & Gottuk, 2006; Miller & Davey, 2007; Preston, 2004; Tannous & Agho, 2019
Social changes in community	Arnold, 2015; Catino, 2015; Clare & Kelly, 2017; Cote et al., 2014; FEMA, 2007; Halonen & Hellenberg, 2006; Preston, 2004; Rutherford, 2018; Stalker & Phyne, 2014

Table 2. *Solutions*

Resources

(48 references; 25 scholarly, 23 grey literature)

Increase recruitment and retention

- year-round, statewide recruitment
 - create a grant system to implement recruitment and retention strategies
 - increase immigration and diversity to reflect the population
 - encourage volunteering for newcomers
 - address relocation concerns
 - promote a good image to the public and positive member relationships
 - provide rewards, recognition, challenge, autonomy, leadership, support, intrinsic and extrinsic motivators
 - have well-trained personnel for all components of response
 - increase staffing investment
- Brooks et al., 2020; Catino, 2015; Cote et al., 2014; Federal Emergency Management Agency [FEMA], 2007; Hirsch & Fuglem, 2006; Hutchins, 2010; Parson et al., 2001; Preston, 2004; Stalker & Phyne, 2014; Tymstra et al., 2020

Administration/ governance changes

- diversify the economic base of communities
 - consider regionalization/ alternate governance: list benefits and drawbacks, use small regions, create inventories of resources
 - job sharing of occupational and environmental health nurse
 - planners and designers in leadership roles
 - separate rural and urban requirements
 - have a clear definition of active firefighter
 - decreasing conflicting and overlapping policies among agencies
 - implement standards for grants, emergency preparedness plans, building materials, residential structures, rural fire departments
- Catino, 2015; Curran, 2018; Fang et al., 2018; Halonen & Hellenberg, 2006; Hammins et al., 2012; Hughes, 2018; Hutchins, 2010; Klein, 2017; Myburgh, 2012; O’Neal, 2017; Preston, 2004; Rutherford, 2018; Stalker & Phyne, 2014; Wainwright & Dhaliwal, 2013
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- pooled resources for hiring and equipment purchase
 - Fire Commissioner’s office accredited and given control over funding allocation to training institutions
 - set targets and expectations for training providers

Invest in infrastructure/ equipment/ protection/planning

- weather instruments
- firehouses
- water-specific
- smoke alarms and residential sprinklers
- long-term funding for Firesmart communities
- modern equipment
- expand road networks

Catchpole, 2000; Catino, 2015; Davis, 2000; Fang et al., 2018; FEMA, 2019; Feng et al., 2016; Forsgren Associates Inc., 2005; Fortune, 2005; Geiman & Gottuk, 2006; Hirsch & Fuglem, 2006; Keller, 2013; Log, 2018; Metallinou & Log, 2017; Moritz & Butsic, 2020; Myburgh, 2012; Parson et al., 2001; Tymstra et al., 2020; Wainwright & Dhaliwal, 2013

Internet-based tools

- fire risk and flashover prediction
- statewide information system for non-career firefighters
- public GIS database of areas of risk
- online fire reporting system
- interactive map of all available water sources

Catino, 2015; Cote et al., 2014; Fang et al., 2018; Klein, 2017; Metallinou & Log, 2018; Verster, 2019

Firefighting tasks

(56 references; 21 scholarly, 35 grey literature)

For individual firefighters

- medical exams, fit for work, review retirement age
- measure risk-taking predictors
- fund alternative health and fitness programs

Eltz, 2015; Hutchins, 2010; Khan et al., 2015; Scott, 2017

-
- environmental stress workshop
 - use core temperature monitoring pills and heat stress wheel

On-scene strategies

- request additional resources as soon as possible
- don equipment in warm areas
- ensure proper warm clothing and protect skin from direct cold
- warm food and liquids for rehab; hydrate
- shorten work cycles
- use removable cleats or spikes
- winter-appropriate apparatus adaptations (e.g., keep engines running)
- use salt/sand to treat ice
- watch for hazards (e.g., swimming pools, stairwells) hidden by snow
- consider extra hose due to snowbanks
- hand-held propane torches to thaw couplings and hydrant caps
- confirm hydrant functionality before use
- additional steps to secure ground ladders

Brouwer, 2007; “Be Prepared for Cold-Weather Firefighting”, 2009; “Important Safety Tips for Winter Firefighting”, 2018; Fortune, 2005; LaFemina, 2019; Log, 2016; Myburgh, 2012; Pindelski, 2011;” The Surprising Risks of Cold-Weather Firefighting”, 2019; Vaughn, 2020

Planning strategies

- extra personnel and equipment, especially at rural stations when risk is high due to weather
- consider travel time delays due to weather
- label primary streets used for response and contact snow removal agency with it
- standardize operating procedures and methods for performance measurement, including for winter operations
- consider seasonal accessibility for apparatus and personnel
- maintenance of pump, apparatus, valves, hoses, fuel tank, caps, plugs, SCBA for cold weather; performance-based winterization

Alexander et al., 2013; Borch et al., 2016; Brouwer, 2007; Cain, 2019; Catino, 2015; Cote et al., 2014; Davis, 2000; “Important Safety Tips for Winter Firefighting”, 2018; Garis et al., 2016; Hughes, 2018; Hutchins, 2010; Keller, 2013; Kennedy, 2018; Khan et al., 2015; Klein, 2017; LaFemina, 2019; Log, 2016; Metallinou & Log, 2017; O’Neal, 2017; Parson et al., 2001; Pindelski, 2011; Rutherford, 2018; Tymstra et al., 2020; Vaughn, 2020; Zehnder, 2017

-
- standardize fill connections across mutual aid group
 - planned water supply network including what-if analysis of new sources; document static water sources
 - adopt hazard identification and risk reduction strategies from other industries or use Homesafe methodology; risk-based response
 - reduce performance targets or primary protection areas
 - proactive planning and design policies and practices; process approach
 - use Rand Institute models for travel time and fire operation
 - Firesmart initiatives
 - participate in grant programs and obtain writing assistance
 - controlled burning/fuel reduction
 - weather station automation/digitization
 - having own firefighting capacity onboard vessels
 - annual Fire Chief survey

Training

- physical/virtual simulations for firefighting and command and control for cold climate, use real cases
- training to identify and monitor risk parameters for natural water supply issues, weather measurement and prediction
- conduct cold-weather outdoor training, including cold injury awareness and apparatus and SCBA training/familiarization
- increase capacity and opportunities for quality training
- regionalization/share expenses between departments
- optimize operations through training with mutual aid departments
- evaluate entry training requirements and timelines
- manage time demands through online, flexible, and mobile training
- leadership development for Fire Chiefs and officers

Alexander et al., 2013; Brouwer, 2007; Catino, 2015; Cote et al., 2014; Curran, 2018; FEMA, 2007; “Important Safety Tips for Winter Firefighting”, 2018; Hamins et al., 2012; Halonen & Hellenberg, 2006; Keller, 2013; Metallinou & Log, 2017; O’Neal, 2017; Pindelski, 2011; Preston, 2004; Tymstra et al., 2020; Wainwright & Dhaliwal, 2013; Zehnder 2017

-
- specialized training office within rescue regions
 - incorporate technologies through fire schools
 - increase oversight and enforcement of minimum training
-

Community

(21 references; 11 scholarly, 10 grey literature)

Increase collaboration

- with Indigenous communities, wildfire managers and operational research specialists, homeowner associations, entities involved in snow removal, police, and stakeholders in creating Firesmart communities
- between departments, agencies, and governments
- encourage diversity and exchange
- recurrent re-evaluation of communities by the insurance service office
- create local committees for risk management
- create an organization for cooperation between entities connected to wildland fire management
- work with school children and families to keep hydrants clear and marked in the snow

Arnold, 2015; Christianson, 2015; Hirsch & Fuglem, 2006; Kennedy, 2018; Log, 2016; Oberndorfer, 2020; Pindelski, 2011; Rutherford, 2018; Tymstra et al., 2020; Vaughn 2020

Education initiatives in the community

- educate about extreme weather risks with demonstrations
 - increased support and targeted education for children
 - home visit program/ proactive partner-based prevention for elderly
 - public and corporation education on fire behaviour and prevention
 - targeted smoke alarm giveaway for high-risk communities
 - programs for proper smoke alarm use and maintenance
 - safety-minded home and appliance design
 - provide incentives to decrease private risk
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Alexander et al., 2013; Clare & Kelley, 2017; FEMA, 2019; Garis et al., 2016; Geiman & Gottuk, 2006; Log, 2016; Metallinou & Log, 2017; Miller & Davey, 2007; Parson et al., 2001; Rutherford, 2018; Tannous & Agho, 2019

4.0 Discussion

The purpose of this review was to identify what information is available about challenges and possible solutions in firefighting and fire service delivery pertaining to cold climate and rural communities. Additionally, we sought to identify areas where future research need is indicated.

4.1 Challenges

The challenges identified in the literature centred around themes of resources, environment, firefighting tasks, and community, with approximately half the references for each theme coming from scholarly literature and half from the grey literature (see Table 1). Specifically, budgetary and capital resource concerns, as well as those related to human resources, were collectively mentioned the most across the literature types. Human resource issues encompassed recruitment, leadership, and administration. The environment theme was also well-referenced across the literature types and included weather-related, land and resource use, and water supply and access challenges. Firefighting task challenges pertained to training, expanding job descriptions and expectations, as well as physical and psychological risks. Challenges pertaining to community centred around social changes, aging communities, and a lack of collaboration. Cold climate challenges were mostly within the environment theme but also included resource and firefighting task challenges. Rural concerns were found in each of the themes.

4.2 Solutions

The solutions identified in the literature also centred around the themes of resources, firefighting tasks, and community (see Table 2). The references pertaining to resource-based solutions were approximately evenly split between scholarly and grey literature. Solutions were presented for increasing recruitment and retention, changes to administration and governance, and greater investment in infrastructure, equipment, protection and planning. The creation of internet-based resources was presented as a solution for risk prediction and public information, fire reporting, mapping of water sources and information for non-career firefighters.

Firefighting task solution references were more likely to come from the grey literature than the scholarly literature. Solutions ranged from monitoring and preventative measures for individual firefighters to specific on-scene and planning strategies, to training recommendations.

Many community-focused solutions centered around increasing collaboration with various stakeholders and groups, within departments and agencies, and through creating committees or other relationships. Education initiatives within communities were often provided as solutions and varied from targeted education for children and the elderly to smoke alarm give-aways and corporate education.

4.3 Further Research Needs Identified in the Literature

Relatively few (six) references were made to future research needs within the reviewed sources, with only one coming from the grey literature. Further study of human characteristics (Khan et al., 2015), addressing gaps in understanding optimal levels and configurations of wildfire management and firefighting resources (Tymstra et al., 2020), measurement of reliability, responsibility, rules compliance

and safety as predictors of high risk-taking behaviours (Eltz, 2015), and attitudes and motivation in the fire service (FEMA, 2007) were specific recommendations for further research. A general recommendation to conduct more research regarding rural fire service was made by Catino (2015), while Kennedy (2018) recommended production, circulation, and application of knowledge in this field.

4.4 Future Research and Application of Findings

Scoping reviews are designed to capture the scope of information available on specific topics and can be used to identify gaps in the current literature and determine opportunities to refine future work (Levac et al., 2010). This review covers literature up to early 2021, and thus prior to the publication of work pertaining to adaptations in the fire service due to the Covid-19 pandemic. As this work emerges, it may address the themes identified here such as remote training adaptations (Wijkmark et al., 2021) and individual firefighter and planning strategies (Belval et al., 2022) in the category of firefighting tasks. Work discussing the intersection of fire service and other issues identified as challenges for rural communities, such as remote tourism (Yu et al., 2018) was not retrieved using the present search strategy and thus should be examined in more specific scoping or systematic reviews.

The next steps in applying the current findings include determining the perceived relevance of specific challenges and solutions to rural Newfoundland and Labrador and the feasibility of implementation.

5.0 Conclusions

Challenges and solutions pertaining to firefighting and fire service delivery in rural and cold climate areas such as Newfoundland and Labrador, Canada, were identified in the scholarly and grey literature. Challenges pertaining to resources, the environment, specific firefighting tasks and the community were referenced equally in the scholarly and grey literature. Solutions presented across the literature were wide-ranging and included ways to increase recruitment and retention, administration and governance changes, increased investments, creation of internet-based tools, interventions for individual firefighters, on-scene and planning strategies, training, and increased community collaboration and education initiatives. Specific firefighting tasks were referenced the most as solutions, followed by resource-related solutions and community-based solutions. Specific calls for more research in the areas of firefighter motivation, rural fire service, measurements of performance and human physical characteristics, as well as exploring management configurations, were made. An additional need for greater dissemination of findings was also articulated.

This review provides a wide range of challenges and solutions for further investigation considering differing contexts and specific research questions in rural, cold climate regions of fire service. In using Newfoundland and Labrador-relevant search terms, it is expected that several of the solutions presented here will, in future studies, be deemed relevant and feasible for implementation in the province.

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