Wildfire Evacuation Challenges in Multi-ethnic Communities: An Information Communication Perspective

Duo Meng
Beijing Normal University, China
duomeng@webmail.hzau.edu.cn

Hu Jun
Beijing Normal University, China
hujun0214@bnu.edu.cn

Chen Anying
Jinan University, China
chenay@jnu.edu.cn

Fang Zhetao
China People's Police University, China
1226442719@qq.com

ABSTRACT

The areas with high wildfire risk of wildfire are inhabited by multiple ethnic groups in China. In the event of a wildfire, there are many challenges for the government to release evacuation information to residents in multi-ethnic communities. Based on the Shannon-Weaver model of communication, a whole-process communication model of evacuation information is constructed to reflect the challenges during the whole process, including the dynamic variability, regional difference and cross-language expression of evacuation information at the stage of information generation, the inadequate communication capability of information carriers and instability of communication infrastructures at the stage of information transmission, and comprehension impairment and irrational perception at the stage of information perception. In response to these challenges, the authors also make some suggestions from the intelligent information technology, crisis response system and offline communication channels.

Keywords

Wildfire, evacuation, multi-ethnic, communication.

INTRODUCTION

Serious wildfires have occurred in many areas around the world recently. In addition to the result of ecological and environmental issues, such as declining air quality and vegetation destruction, they also pose a threat to human life and property safety. When a wildfire breaks out, except taking appropriate fire extinguishing, evacuating the residents around the fire in time is also important. The current research on wildfire evacuation is mainly carried out from the following aspects: (a) the influence factors on wildfire evacuation decisions. McCaffrey et al. (2018), McLennan et al. (2019), and Toledo et al. (2018) have analyzed the factors that affect residents' evacuation actions in wildfire scenarios. (b) the modeling and analysis of the evacuation process. Wang et al. (2021) constructed an evacuation model of forest tunnel fire based on the characteristics of smoke diffusion. Beloglazov et al. (2016) constructed a simulation of wildfire evacuation with dynamic factors and model composition, and evaluated the effectiveness of an evacuation. Cohn et al. (2006) analyzed the evacuation behavior during wildfires through case studies. (c) the evacuation risk from the perspective of local community and infrastructure. Cova et al. (2013) analyzed the limits of infrastructure on wildfire evacuation vulnerability, and Beverly et al. (2011) analyzed the impact of housing and roads during the wildfire evacuation process.

Some studies have also focused on the issue of information communication for wildfire evacuation. When a wildfire occurs, it is crucial for the public to receive timely information on evacuation (Stidham et al., 2011). McCaffrey et al. (2013) highlighted the importance of disseminating information in as timely a manner as possible

and through sources that allow as much interaction as possible with information providers. Li et al. (2021) demonstrated the efficacy of using social media to aid evacuations. Cao et al. (2016) believed that an optimal communication approach would be to couple map designs with several imperative textual descriptors, and Vélez et al. (2017) found that television is the primary source for information seeking during wildfires. Generally, these studies are conducted from the view of information receivers, namely the local residents at risk during a wildfire, and analyzed their attitudes and tendencies towards different information sources. However, there are few relevant research from the perspective of information communication process, and the information characteristics such as the timeliness and accuracy, which are also meaningful for wildfire evacuation, are not considered in-depth. Furthermore, community characteristics like multi-ethnic could also exert influence on the communication process, but relevant research is also lacked.

In this research, we will discuss the challenges of information communication during the wildfire. The study areas are the areas with high risk of forest fire in China, which are also the regions with multi-ethnic communities. Based on fire statistics, the current wildfire risk of China is presented. Then, from the perspective of evacuation information communication, this paper analyzes the challenges of information communication in these multi-ethnic areas with high wildfire risk. Finally, a whole-process communication model of evacuation information is constructed to reflect the challenges during the information communication process, and some suggestions are also provided.

THEORETICAL FOUNDATION

Getting the urgent information is the primary step before the public can take response actions. In general, whether the public can get the information in time is related to three factors: (1) The characteristics of the messages. The characteristics of the messages include the languages in which the messages are expressed and the forms of the messages (text, video, audio, etc.), which will have an impact on the accuracy, reliability and understandability of the information. (2) The transmission capacity of information carriers. For different information carriers, such as television, radio, online social media, and face-to-face communication, the speed and scale of information transmission are different, affecting the timeliness and population coverage of the information. (3) The comprehension capacity of the information receivers. The information needs to be understood and recognized after receiving it, and the comprehension capacity is related to the individual characteristics of the information receivers, including the age, career, education level, audio-visual condition, previous disaster experience and so on.

In this research, we mainly focus on the communication process of evacuation information during a wildfire. A classic theoretical model in communication research is the Shannon- Weaver Model (see Figure 1.), a process model of communication proposed by Claude Shannon and Warren Weaver in 1948 (Shannon, 1948). It is a transmission model consisting of six elements:

- Sender, the information source that produces a message;
- Encoder, the transmitter that encodes the message into signals;
- Channel, to which signals are adapted for transmission;
- Decoder, the reception that decodes (reconstructs) the message from the signal;
- Receiver, the destination where the message arrives.
- Noise, a dysfunctional factor.

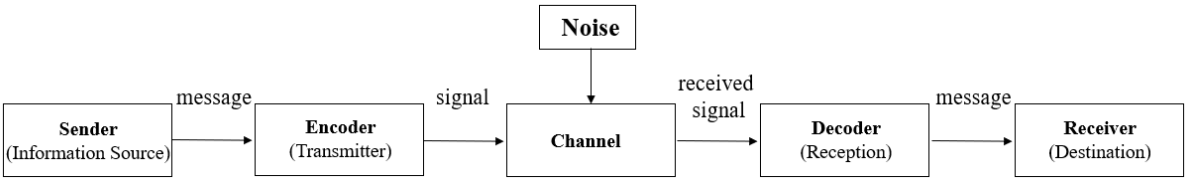

Figure 1. The Shannon-Weaver Model of Communication

The main feature of this model is the introduction of the concept of "noise", which refers to any interference with the message travelling along the channel and may lead to the signal received being different from that sent. It is a very linear model, and it does not even include a feedback loop. In our research, we focus on the linear process from official release to public reception of emergency information, so the Shannon-Weaver Model is adopted.

In this model, the sender will generate and send out the evacuation information to the receivers. For example, the local government or fire department can be considered as the sender during a wildfire, while the receivers are the

residents in the wildfire-affected regions. And the intermediate process from encoder to decoder can be regarded as the process of information transmission, including the channels of television, radio, SMS, online social media and so on. In addition, according to this theory, noise will occur in the process of information transmission, such as the unofficial and untrue rumors.

RESEARCH AREA

In this research, we will discuss the wildfire evacuation challenges in the regions with high risk of wildfire in China. There are great differences in natural conditions such as topography and climate among different regions in China, leading to the obvious regional differences in the risk of wildfire. Forest fire is a typical wildfire characterized by sudden and intense outbreaks, significant destruction, and challenging rescue efforts. The relevant data on forest fires in China from 2012 to 2021 provided by the *China Forestry Statistical Yearbooks* (2012-2021) reflects the occurrence of forest fires during this decade, and Figure 2 represents the total number of forest fires in each province of China according to the data. It can be observed that over the past decade, forest fires have predominantly occurred in the central and southern regions of the country, which is closely associated with differences in natural conditions such as topography and climate among these regions. In the north, the forest fire mainly occurs in Inner Mongolia. Specifically, Inner Mongolia, Shaanxi, Sichuan, Hubei, Hunan and Guangxi are identified as regions with a high incidence of forest fires and the total number of forest fires in Guangxi exceeded 4,000.

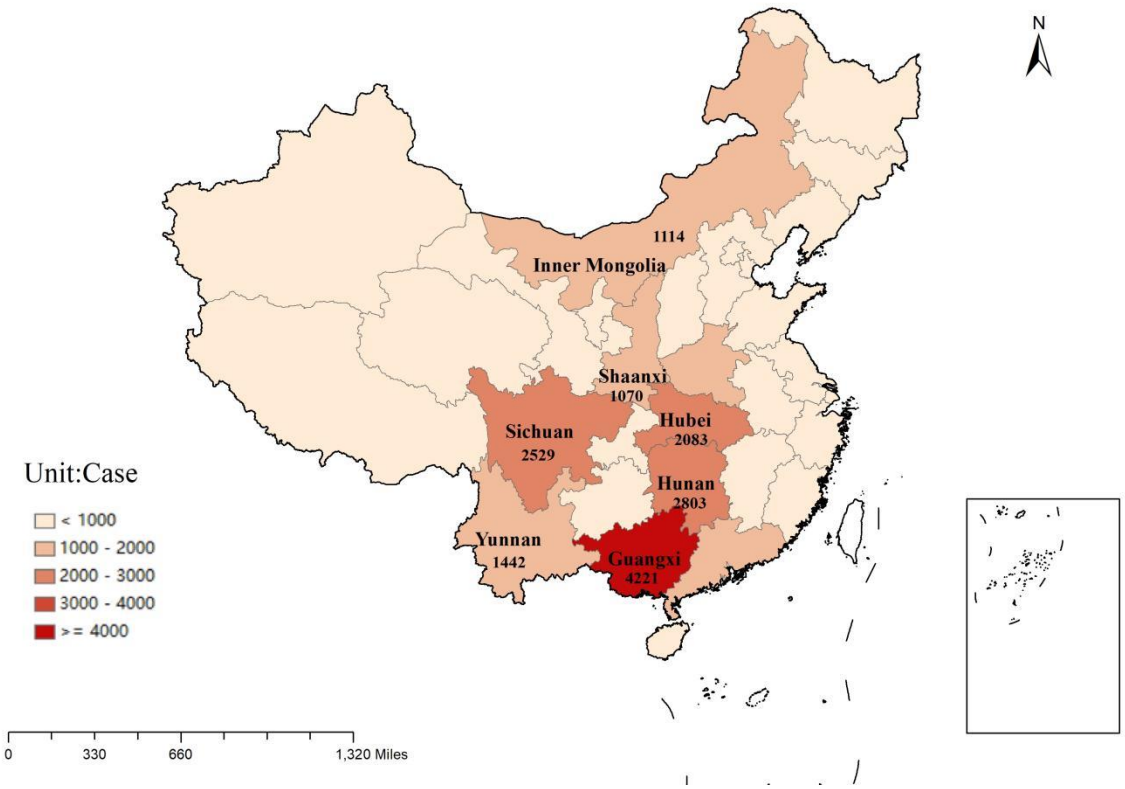

Figure 2. Total number of forest fires in each province of China (2012-2021)

The consequences of forest fires are serious. Figure 3 shows the number of forest fire casualties in China. Over the past decade, a total of 480 individuals have been reported to be injured or lost their lives due to forest fires, and the highest number of casualties was recorded in 2014, reaching 112 individuals. The provinces of Sichuan, Yunnan, Guangxi, Hunan, and Shaanxi have experienced a relatively higher number of casualties from forest fires. With regards to the damage to the ecology, the total damaged forest area has reached 133,000 hectares over the past decade. Figure 4 shows the affected forest area and total fire area in China. In 2014, the total fire area reached a peak of 55,341.4 hectares, and the affected forest area also reached a relatively high level of 19,111.1 hectares. In the subsequent years, both the affected forest area and total fire area showed a fluctuating decline and respectively reached 4,458 hectares and 14,125 hectares in 2021. Overall, the ecological damage caused by forest fires in China has been gradually decreasing, but the potential dangers still exist and should not be neglected.

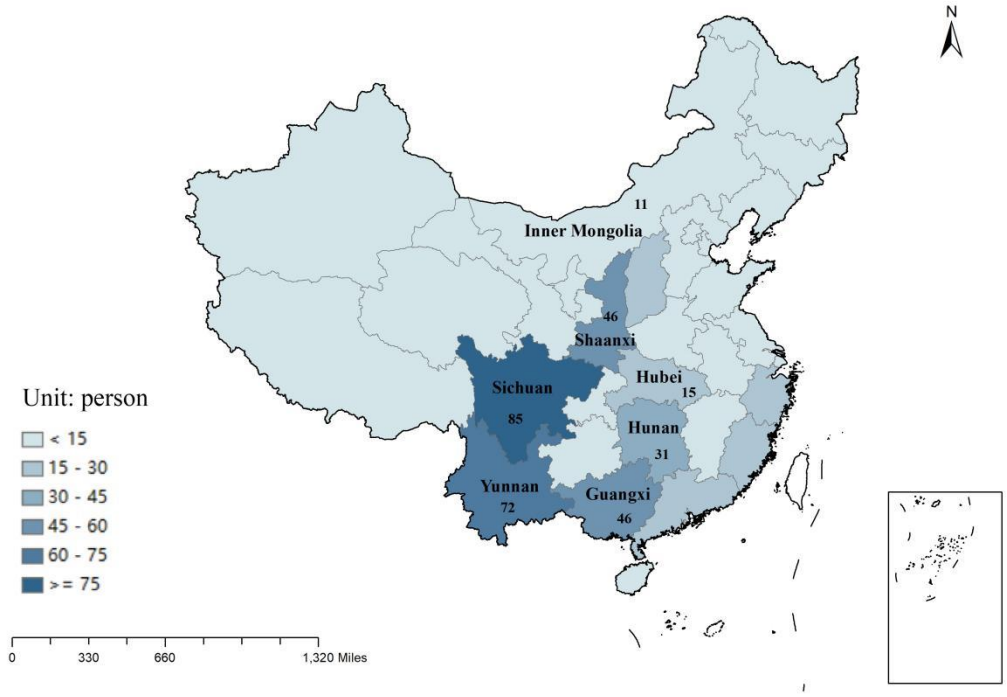

Figure 3. Total number of forest fire casualties in each province of China (2012-2021)

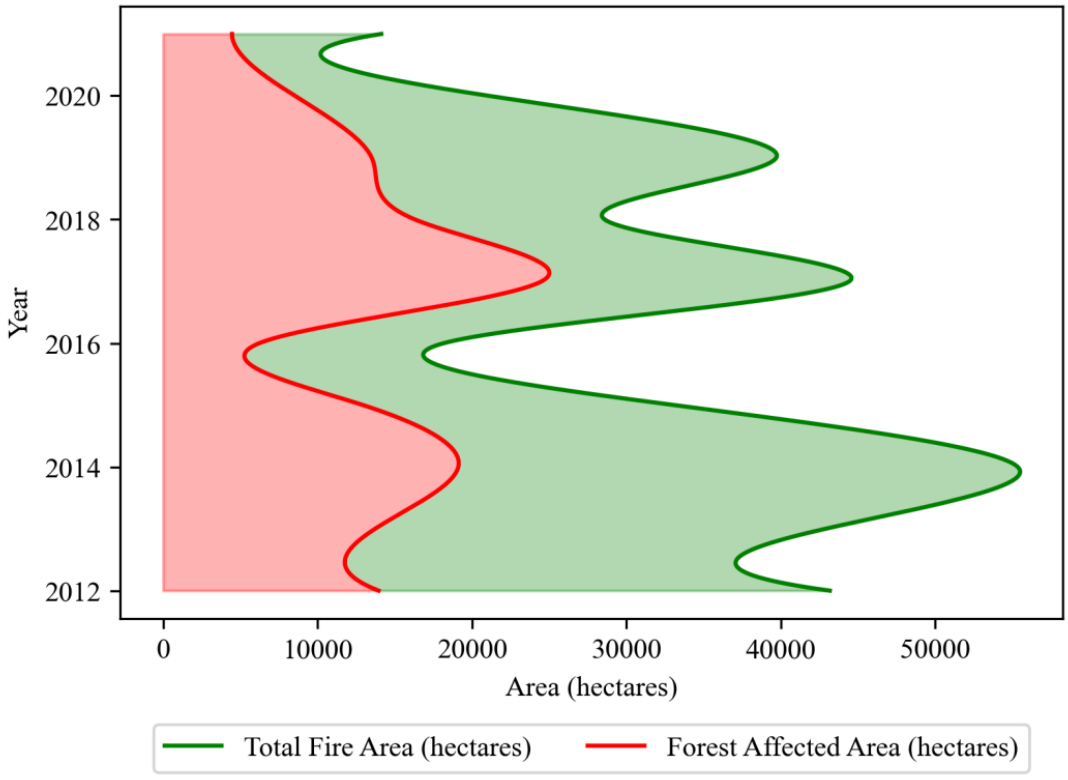

Figure 4. Total fire area and forest affected area over years (2012-2021)

Meanwhile, those serious and massive fire accidents should also be taken seriously, as they have caused serious casualties or losses. A serious case was happened in Liangshan, Sichuan Province, on March 30, 2019, which has caused 31 deaths. The brief information of several serious and massive large fire cases is shown in Table1.

Table 1. Cases of serious and massive forest fires happened in China (2012-2021)

Date	Location	Casualties or losses
Apr.16,2014	Kunming, Yunnan Province	210 hectares of forest burned
May.02,2017	Daxinganling, Inner Mongolia	About 8282.58 hectares of forest burned
Mar.30,2019	Liangshan, Sichuan Province	31 deaths
Dec.05,2019	Lianping, Guangdong Province	427.3 hectares of forest burned
Mar.30,2020	Liangshan, Sichuan Province	19 deaths and 3 wounded, 427.3 hectares of forest burned
Jun.07,2020	Changjiang, Hainan Province	About 358 hectares of forest burned

CHALLENGES: INFORMATION COMMUNICATION ON WILDFIRE EVACUATION

When a wildfire occurs, the timely information on evacuation is important to the public. The government will release evacuation information to residents in those communities which are deemed to be in need of evacuation to minimize potential casualties. However, there are many challenges in the actual implementation of the program.

Multi-ethnic Characteristics of Information Receivers

In the above section, we have analyzed the current situation of forest fire risk in China, and the areas with high wildfire risk include Inner Mongolia, Shaanxi, Sichuan, Hubei, Hunan, Yunnan and Guangxi provinces. In fact, these areas are also ethnically diverse. Figure 5 illustrates the current status of multicultural integration in these provinces according to *National Bureau of Statistics* (Office of the Leading Group of the State Council for the Seventh National Population Census, 2020). It can be seen that these provinces have a high proportion of ethnic minority populations apart from the Han, the largest population in China.

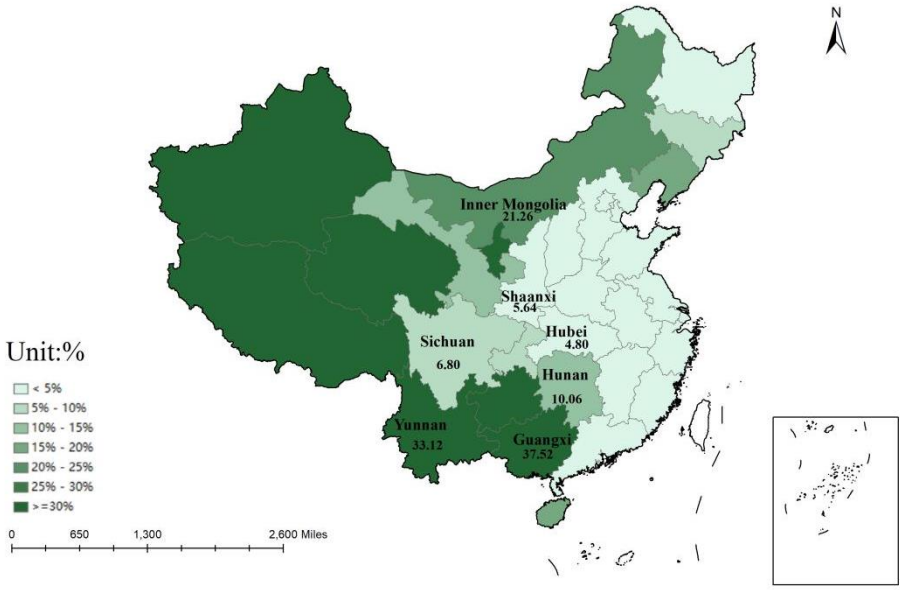

Figure 5. Proportion of ethnic minority population in China (2020)

Due to the small proportion of these ethnic groups, the emergency information is primarily published in Mandarin, the official Chinese language. For some ethnic minority residents, they may not speak or understand Mandarin clearly. This is a great challenge in the information communication on evacuation when a wildfire occurs. The diversity of ethnic minorities in these regions presents a requirement for the accurate information in their native languages.

Challenges for Communication of Evacuation information in Multi-ethnic Communities

According to the Shannon-Weaver model, the process of information communication can be divided into three

main stages: the generation and release of information, the transmission of information and the perception of information. When a wildfire occurs, there are some challenges for government departments to release evacuation information to residents in multi-ethnic communities. According to the process of information communication, the challenges are sorted as follows.

Generation of Information

At this stage, the government needs to generate a reasonable evacuation strategy for the public based on the real-time fire situation. In multi-ethnic areas, there is also a need to express in multiple languages. The challenges at this stage are:

- Dynamic variability of evacuation information. The accuracy of evacuation information is closely related to the real-time state of the fire. The development of the wildfire is dynamic, so it is necessary to dynamically update the evacuation information and release it to the public according to the real-time state, rather than a single information. For example, as the fire grows, the evacuation routes, available shelters, and available safe evacuation time in the information need to be modified.
- Regional difference of evacuation information. In the event of a wildfire, the risk exposure of residents in different regions is different, and in order to avoid possible evacuation congestion, the evacuation information (especially the evacuation routes) in different areas should be different.
- Cross-language expression of evacuation information. In multi-ethnic communities, considering the native language of different ethnic groups, it is also necessary to pay attention to the multilingual expression of evacuation information to meet the information requirements of different ethnic groups.

Transmission of Information

After the evacuation information is generated, the government will release the information through TV, radio, SMS, online social media and so on. Generally, when a wildfire occurs, government authorities use three main channels to release evacuation information to the public in the digital era: (a) Cable broadcasting and television (these two carriers are often reported together as an indicator in China). The emergency information was released through news bulletin or scrolling marquee in the television. In this channel, the length of the information is limited. (b) SMS (Short Messaging Service). When emergencies occur, the government departments compile the emergency information, and the mobile phone operator will release it to users through SMS (Short Messaging Service). This channel also has a limit on the number of words, but it supports the partitioned release of information, that is, the information for different regions can be targeted. (c) Online social media. Emergency information is released on online social networks by official accounts. The advantage of this channel is that there are fewer restrictions on the length of the information.

The popularity of these information carriers is investigated, and their penetration in the multi-ethnic areas with high risk of wildfire is shown in Figure 6, according to the statistics (National Bureau of Statistics, 2022; China Internet Network Information Center,2022). The penetration condition can represent the emergency information coverage in emergency scenarios to some extent.

It can be observed that the mobile phone and Internet are becoming mainstreams, while the penetration of traditional channel, the cable broadcasting and television are relatively low. The popularity of mobile phones is relatively high, and the rates in these high-risk provinces are all over 100%, which means that the use of SMS can achieve full information coverage statistically. However, it should be noted that the mobile phone penetration rate is calculated as the average number of mobile phones per 100 people, and some citizens have more than one mobile phone, while some may not have a mobile phone (especially for the elderly). So, it is improper to release information only with SMS. As for the Internet, the penetration rate in each province is more than half, but there are also differences among provinces, which is related to the level of economic development of the region. Regions with a low level of economic development, such as Yunnan Province, have low Internet penetration relatively.

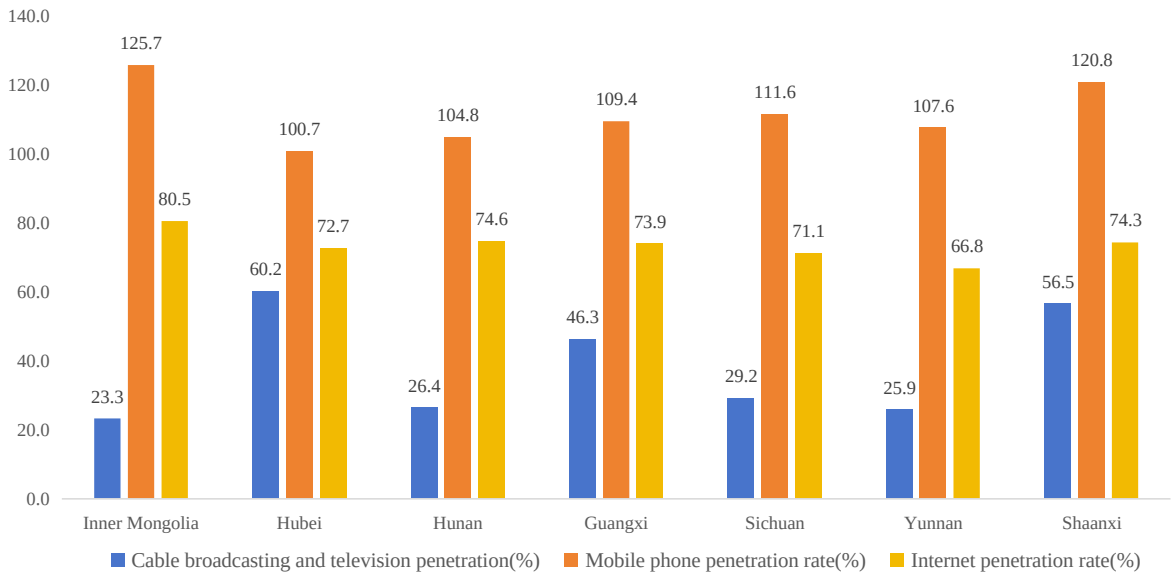

Figure 6. Penetration of Information Carriers in several provinces of China

To summarize, the challenges at the stage of information transmission are:

- Inadequate communication capability of evacuation information carriers. Unlike developed countries, the level of informatization in many developing countries, including China, still needs to be improved. The above analysis of penetration of several information carriers shows that the coverage and spread speed of information carriers in China are still insufficient. In the event of a wildfire, it is likely that not all the residents can receive evacuation information in time.
- Instability of communication infrastructures. In the case of wildfires, it is necessary to take into account the damage to communication infrastructures caused by the fire. Many communication infrastructures, such as the cell phone towers, are located in the wild, and they may be burned when a wildfire occurs, leading to the inability to receive the evacuation information from SMS in the local area.

Perception of Information

After receiving evacuation information through various channels, the residents still need to accurately understand the evacuation information. Apart from the individual differences, the following challenges still exist for the perception of evacuation information in multi-ethnic communities:

- Comprehension impairment due to non-native language or formalization. The evacuation information is primarily published in Mandarin, so the ethnic minority residents may not understand it clearly and rapidly if Mandarin is not their native language. Except for the language barrier, the difference between official expression and the colloquial expression will also make the public understand the emergency information differently. For example, the official naming of specific roads and locations mentioned in the evacuation information may be different from the naming of local residents, which will lead to a sense of unfamiliarity and misunderstanding of evacuation information for the public.
- Irrational perception in crisis situations. When a wildfire occurs, the evacuation information may be selectively ignored and filtered by the residents. Neuroscientists believe that the mechanism by which the human brain selectively ignores and filters information is closely related to the state of activity of neuronal networks. When the brain perceives a threat or an emergency situation, the state of activity of the neuronal network changes in order to better process and transmit information related to these situations. In a wildfire emergency, when the public receives the evacuation information, they may realize that they are in danger and "need to evacuate", but "how to evacuate" (the information on evacuation routes) mentioned in the evacuation message may be ignored, and the evacuation routes may be chosen according to personal experience.

MODEL AND SUGGESTIONS

On the basis of Shannon-Weaver Model, considering the characteristics of wildfire development and information

communication in multi-ethnic communities, a whole-process communication model of evacuation information in multi-ethnic communities is constructed as Figure 7, which also summarizes the challenges and possible responses in each segment. In this model, the official emergency evacuation information publisher, namely the local government or fire department, is considered to be the sender, which generate and send out the evacuation information to be transmitted; and the receivers are the residents in the wildfire-affected regions, who will receive the evacuation information during a wildfire. And the intermediate process from encoder to decoder can be regarded as the process of information transmission, including the channels of television, radio, SMS, online social media and so on. In addition, noise will occur in the process of information transmission, mainly in the form of unofficial and untrue rumors, as well as the interference to the accuracy of information by the dynamic wildfire condition.

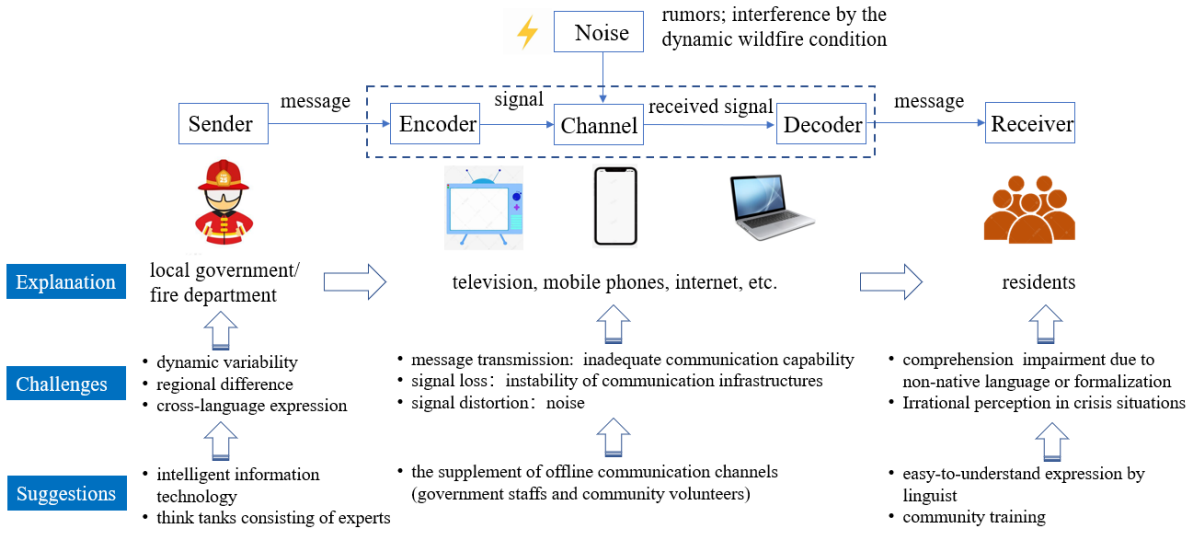

Figure 7. Whole-process communication model of evacuation information in multi-ethnic communities

In the process of communication, various challenges can affect specific segments, as evidenced by the following: when generating evacuation information from the sender, the dynamic variability and regional difference of evacuation information need to be considered, as well as the cross-language expression; in the process of information transmission, the communication capability varies among different information carriers (television, mobile phones, internet, etc.), and there may be regional signal loss or interruption due to damage of communication infrastructures, as well as information distortion due to the addition of noise; when the public receives the information, barriers to information comprehension due to non-native language, formalization, and the problem of irrational perception in crisis situations may make it hard to accurately and fully understand the evacuation information.

In response to these challenges, the authors make some suggestions:

First, the application of intelligent information technology. At present, with the development of artificial intelligence (AI) technology and the optimization of Large Language Models (LLM), the accuracy and speed of machine translation are constantly improving, and these intelligent technologies can be used to assist the release of information in emergency situations. Intelligent machine translation can utilize machine learning, deep learning, and other technologies to train models to recognize multilingual information and automatically generate the appropriate content for information release. With the help of intelligent machine translation, the time for translation of information can be reduced, ensuring the timely and rapid release of information, and the multi-language information can improve the comprehension of multi-ethnic receivers.

Second, the improvements to the crisis response system. China's crisis response system focuses on government-led and multi-party participation, relying on modern technological means and emphasizing early warning and prevention, rescue and relief, and post-disaster recovery, in order to safeguard the safety of public life and property and social stability. However, there are still some deficiencies in the way the current crisis response system operates for the issue of wildfire. For example, there is a lack of timely updated evacuation information and a lack of scientific basis for decision-making, all of which will affect the effectiveness of wildfire response in China. Therefore, we propose to start improving the way the system operates from the following two perspectives in order to increase its efficiency: a) strengthening the evacuation training of the community. Frequent training could help to reduce irrational behaviors of residents in critical situations, so that they can understand the evacuation information more calmly and accurately. b) Establishing organization of think tanks consisting of experts on fire

science, psychology and linguistics. The experts will cooperate with government departments and support decision-making in emergency scenarios, so that the dynamic scenarios of wildfires can be judged more accurately, and the evacuation information can be released and updated with a reasonable frequency and easy-to-understand expression.

Third, the supplement of offline communication channels. Many elderly people seldom use digital communication tools (mobile phones, laptops, etc.), especially for those from ethnic minorities, causing the barriers to receive emergency information. In addition, those with audio-visual impairments are unable to receive information in ordinary form. For these groups, offline face-to-face communication by government staffs and community volunteers is crucial. Meanwhile, the offline channels convey more accurate information, as the information provided by the government staffs and volunteers is official, avoiding the interference of possible rumors (noise). Therefore, despite the obvious disadvantage of inefficiency, the offline channels of information communication remain irreplaceable. In particular, in extreme cases where communication infrastructures are completely destroyed and wide-scale communication cannot be achieved through communication tools (mobile phones, telephones), door-to-door service by the government staffs and volunteers in the communities will be the most reliable form of information communication. At the same time, by carrying shouting or broadcasting equipment, drones can convey instructions, safety alerts and other information to the affected people, improving the public's ability to respond to emergencies.

CONCLUSION

The timely and accurate evacuation information is crucial for the residents during a wildfire. In China, the regions with high wildfire risk are also inhabited by multi-ethnic people, posing some challenges to the communication of evacuation information. In this research, the specific challenges are analyzed with a whole-process communication model, from the generation to the perception of evacuation information.

As a supplement to other research on the public evacuation behavior and decision, the challenges during the information communication are pointed out in this work, and some practical suggestions are also provided. In this work, the study areas are the multi-ethnic areas with high risk of wildfire in China, but the research is also applicable to other areas around the world, as some areas of the world with high wildfire risk are also inhabited by multi-ethnic residents. So, the discussion is helpful and can be served as a reference for the release of information in wildfire situations. Further research on how to solve these problems are still needed, especially on how to provide evacuation with regional difference and cross-language expression, and quantitative analysis on comprehension impairment due to non-native language and public perception in crisis situations.

Due to time constraints, it is not possible to obtain sufficient data at this time. However, we are conducting field studies to collect more specific data. We also plan to conduct an in-depth analysis using more quantitative communication science models, which will help to more accurately assess and explain the issues involved in the study.

ACKNOWLEDGMENTS

This work was supported by GuangDong Basic and Applied Basic Research Foundation [grant number 2023A1515110301&2022A1515110347]; Guangdong Philosophy and Social Science Planning Project [grant number GD23YGL36]; and the Fundamental Research Funds for the Central Universities [grant number 23JNQN09].

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