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ARTICLE

Appetite for Natech Risk Information in Japan: Understanding Citizens' Communicative Behavior Towards Risk Information Disclosure Around Osaka Bay

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Abstract Effective risk communication is essential for disaster risk management. Apart from empowering communities to make informed risk choices, risk information disclosure can also drastically enhance their disaster preparedness, especially concerning conjoint scenarios of technological and natural hazards (Natech). A fundamental precondition is the actual demand for such information. This study ventures to assess whether residents around Osaka Bay have this demand, or "appetite," for risk information disclosure, as well as to understand their communicative behavior and perceived challenges in the Japanese context through the prism of the Situational Theory of Problem Solving. To test this framework under realistic conditions, data were collected through a household questionnaire survey from two urban areas near industrial complexes in Osaka Bay. The results show that identifying Natech risk information deficiency as a problem was not a statistically significant predictor for individuals' motivation to communicate. However, their motivation increased as their perceived personal involvement with the situation rose, while the perceived obstacles in doing something about it exerted a negative influence on their motivation. Individuals' motivation intensified their communicative actions to solve this problem. Public segmentation underscored the elevated public perceptions concerning the issue of risk information deficiency in nearly nine out of ten respondents. These findings indicate a strong community appetite for chemical and Natech risk information, which subsequently led to high situational motivation to engage in communicative action, particularly information acquisition. Risk management policy is suggested to focus on introducing chemical risk information disclosure regulatory initiatives to encourage citizen engagement.

Keywords Japan · Natech risk information · Participatory risk management · Risk communication · Situational Theory of Problem Solving (STOPS)

1 Introduction

Active community involvement in disaster risk management is widely acknowledged as one of the key factors for effective disaster risk reduction, and the contribution of risk communication towards this goal has been explicitly emphasized by academics and practitioners alike over the past few decades (Samaddar et al. 2017). This discussion gains specific importance in consideration of large-scale complex disasters, for instance technological accidents triggered by natural hazards, otherwise referred to as Natech—concurrent events that occur when there is a hazardous material release as a result from the impact of a natural hazard on installations that handle these materials (Krausmann et al. 2017). These events are defined as technological accidents caused by a natural hazard that involve the accidental release of hazardous substances (UNDRR-APSTAAG 2020). The extent and severity of such complex disasters demand multidimensional

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responses that include actors from the government, businesses, and local communities for the purpose of addressing the associated risks effectively (Shimizu 2012).

Within this context of chemical and Natech risk communication, the motivation for this research is founded on two pillars. First, the notion that a community's right-to-know (Baram 1984; Hadden 1989) is not only a simple legislative matter, but rather an empowering risk communication approach (Hadden 1989). Strategic risk communication emphasizes relationship building through a continuous, civic dialogue on the basis of right-to-know initiatives in order to address public risk-related concerns and perceptions (Palenchar 2008). However, a community's right-to-know is exactly that—a right. Citizens[1] are not always obliged to be aware of the risk they are subject to, but ideally, they should have the choice of exercising their right to know. Thus, the second pillar is the argument that effective risk communication is not only about what risk management researchers and practitioners believe citizens need to know, but also about what people actually want to know (Klinke and Renn 2010). That said, currently in Japan there seems to be little to no information provided to households living near industrial parks concerning the prevention, mitigation, and suggested preparedness measures in case of chemical-release accidents and Natech hazards. In order to develop meaningful risk communication strategies, disclosing such risk information should align with the perceived needs of the community. Given these circumstances and following the above narrative, it is interesting to explore whether citizens in Japan have this demand, or "appetite," for risk communication and information disclosure concerning these hazards.

The main research question is: What is the communicative behavior of citizens towards chemical and Natech risk information disclosure in Japan? Communicative behavior here refers to how individuals communicate about the issue, that is, what communicative actions they engage in with regard to searching for, selecting, and sharing information with others. The current research project ventures to assess whether communities have an appetite for Natech risk information disclosure and risk communication, as well as to understand their communicative behavior patterns and perceived challenges in the Japanese context through the prism of the Situational Theory of Problem Solving (STOPS). Investigating and evaluating how citizens perceive the issue of Natech risk information deficiency, how motivated they are in resolving it, and how they communicate about it can inform risk management policies and help design effective risk communication strategies to address specific informational needs and concerns of key audiences. From an academic standpoint, this study is the first test of the STOPS model in Japan and in the disaster risk management context, particularly considering Natech accidents. Due to limited research on the emerging subject of Natech risk information disclosure, and considering that Natech are essentially chemical accidents triggered by natural hazards, this study begins its approach to risk communication from the broader view of chemical risk information disclosure.

Section 2 offers an overview of chemical risk information regulation, presents the academic discourse around risk information disclosure for participatory risk management, introduces the rationale for selecting STOPS to investigate citizens' communicative behavior, and explicates the methodological framework. Section 3 describes the research objectives and data collection. Section 4 discusses the employed multivariate and descriptive analysis methods. Section 5 evaluates the structural model's performance before testing the research hypotheses. Section 6 synthesizes the research findings, interpreting citizens' communicative actions and concluding with policy implications. The study's limitations are presented in the next section, followed by a summary and the consideration of future research prospects.

2 Risk Communication and Chemical Information Disclosure

Risk communication and information disclosure concerning chemical accidents entails public access to appropriate information so that potentially affected communities can be aware of the hazards and risks from nearby hazardous installations, and are prepared to act appropriately in case of an accident—see the Guiding Principles for Chemical Accident Prevention, Preparedness and Response (OECD 2003). In this context, we approached the topic of Natech risk communication by looking at how certain regulatory frameworks govern access to chemical risk information, before exploring the academic discussion about the relationship between right-to-know initiatives and chemical accident risk management.

2.1 Chemical Risk Information Disclosure Regulation

There are two pieces of legislation that stand out in the international arena—the Emergency Planning and Community-Right-to-Know Act (EPCRA 1986) in the United States (US) and the Seveso Directives (1982/501/EEC, 1996/82/EC, and 2012/18/EU) in the European Union (EU). There is no common global framework on chemical

[1] The term "citizen" in this article refers to lay persons or social actors that comprise "publics, social groups and communities" (Kennedy 2016).

risk information disclosure yet, and so countries develop their own legislative approaches. South Korea's latest Chemicals Control Act (Ministry of Environment, Republic of Korea 2018), for example, introduced regulations for disclosure of chemical accident risk information to communities near industrial facilities that handle potentially hazardous materials. Japan presents a different case in the field of technological and chemical hazards. In spite of the country's world-renowned expertise in disaster risk management—especially in coping with natural hazards—Japan's stance on chemical risk communication and information disclosure led Ikeda (2014) to conclude that the country seems to lag behind the US and the EU in terms of regulatory frameworks.[2]

The presently active legislation that defines the disaster prevention framework in Japan, the Disaster Countermeasures Basic Act (National Land Agency, Government of Japan 1961), makes no reference to technological or chemical risks. Requirements for industries to report hazardous chemicals inventories and publicly share such data are not included. The only regulatory article that explicitly requires industrial facilities to publicly disclose information regarding dangerous substances is found within the Pollutant Release and Transfer Register Law (PRTR) and the Promotion of Chemical Management (Cabinet Office, Government of Japan 1999). The PRTR system dictates that businesses handling chemicals potentially harmful to the environment are obligated to estimate the volume of such releases, and report the data to the local governments. The national administration compiles this information and publishes the results to the citizens on an annual basis.[3] However, this regulation aims at monitoring the environmental discharge levels of specific toxic chemical substances. The framework does not apply to future scenarios that involve releases of hazardous materials caused by technological or Natech accidents with potentially severe consequences for local communities and/or the environment. In comparison to Japanese regulation, EPCRA in the United States requires chemical companies that handle hazardous substances to publicly report their chemical inventories and their environmental releases to local communities, while in Europe, the Seveso III Directive mandates that on-site contingency and emergency response plans for dealing with accident scenarios have to be openly shared with the potentially affected population.

There seems to be little to no information disclosure concerning chemical—and by extension Natech—accident risk in Japan. Notable efforts have been made from the government side to address this issue concerning nuclear disaster management, by forming a Nuclear Regulation Authority that holds public hearings and discloses regulatory information pertaining to the related decision-making processes (Disaster Management Bureau 2015), yet the question remains for chemical accident risk. Scholars who looked into the developments of risk communication in Japan in the post-Fukushima era noted that this scarcity of publicly available chemical risk information has resulted in little preparedness from the citizens' standpoint to address low-probability, but high-impact technological accidents (Hasegawa 2013; Ikeda 2014; Kinoshita 2014). A recent study that examined risk perceptions and evacuation behaviors at the household level following the Fukushima accident also highlighted the challenges for community preparedness against accidents given the overall lack of publicly available chemical risk information to local residents (Yu et al. 2017).

2.2 Right-to-Know and Participatory Risk Management

Many disaster risk reduction practitioners and scholars place the emphasis on bottom-up approaches, which encourage risk communication throughout policy making in order to promote more participatory methods in risk management (Fekete 2012). Transparency and dissemination of risk information have been widely recognized as essential elements in cultivating a milieu of trust between institutions and communities, and go a long way towards encouraging participation in risk reduction processes (Burby et al. 2003; Klinke and Renn 2010). Actors from all backgrounds are urged to engage in the risk-related decision-making processes and codesign the discussion framework. Risk communication and open access to related information is important from an ethical practice standpoint, as it promotes the accountability of involved stakeholders and allows risk-informed decision making (Sellnow et al. 2009). The views of citizens, social groups, businesses, and institutions are equally valuable in deciding collaboratively suitable ways of coping with risk (Pandey and Okazaki 2005; Klinke and Renn 2010; Figueroa 2013).

Several researchers examined such participatory risk management approaches in Japan focusing on chemical and Natech risk. Figueroa (2013) looked at risk communication after the Fukushima nuclear disaster. Taking as an example the way public hearings discussing nuclear power plant construction have been conducted in Japan, he concluded that public participation remained a formality rather than an opportunity for substantial dialogue between

[2] Ikeda (2014, p. 632) noted: "we were far behind the US and EU countries in starting regulatory reform from the paternalistic top-down to the informed choice on risk under proper institutional setting in Japan."

[3] Japanese Pollutant Release and Transfer Register (PRTR) data are available from the website of the Ministry of Environment, Government of Japan at https://www.env.go.jp/en/chemi/prtr/prtr.html.

communities and regulators. Apart from the characteristically scant government efforts to engage in risk communication pertaining to chemical accident hazard in Japan (Yu et al. 2017), a household survey by Yu and Cruz (2016) also revealed that citizens felt that there were no community initiatives to disseminate information and prepare for chemical or Natech accidents.

Overall, academics delineated a picture of no meaningful public participation in Japan (Mochizuki 2014; Shimizu 2016). In terms of chemical and Natech risk, communities seem to be mainly—or just—passive receptors of the little risk information made publicly available. Other researchers, however, noted a surge in citizen activism recently, and suggested that this situation might be gradually changing, as communities have been proactively seeking out opportunities to become involved in risk-related policy making since the Fukushima accident (Figueroa 2013). Bearing in mind that "it is not the task of the communicators to decide what people need to know but to respond to the questions of what people want to know" (Klinke and Renn 2010, p. 24), a crucial first step is to evaluate the risk communication context in Japan so as to better understand the current concerns and perceptions of communities.

2.3 Previous Research on Chemical Risk Information Disclosure

Much of the academic discourse has been devoted to understanding the lay audience's cognitive beliefs and risk perceptions as influencing factors of risk communication—for comprehensive reviews see Slovic (2000) and Wachinger et al. (2013). Only a small portion of the literature touches on the subject of risk communication from the perspective of communities' right to demand public disclosure of chemical information. Palenchar (2008) carried out an ethnographic case study in Texas, attempting to shed some light on citizens' perceptions and level of awareness regarding federally mandated right-to-know initiatives in the United States. He observed a generalized absence of awareness and basic understanding of community right-to-know initiatives from the citizens' standpoint. These findings show that local residents were far from making any claims on their right to be informed about the chemical risks they were subject to, despite the appropriate regulation being in place to allow them to do so. Moreover, he recognized that additional research from a variety of disciplines is required so as to appreciate the role of the community right-to-know in risk communication.

The topic of Natech risk perception and communication has only just begun to emerge in the academic discourse, and therefore there are no studies that explore the citizens' views on information disclosure. Previous attempts to delineate the characteristics of effective risk communication strategies and active community participation in risk management processes mainly explore cases where lay people have already been exposed—if not accustomed—to right-to-know initiatives, for example, Slovic (2000), Kapucu (2008), and Palenchar (2008) in the US, and Wachinger et al. (2013) and Sjöberg and Drottz-Sjöberg (2009) in the EU. Since the right-to-know was already embedded in the respective chemical risk regulation framework, it could be argued that such studies presupposed the citizens' willingness to actively participate in the risk management processes. Consequently, the issue of citizens' demand or "appetite" for chemical and Natech risk information deserves more attention from risk communicators, and warrants further study, particularly so in the context of Japan. A fundamental question remains unanswered: What is the communicative behavior of citizens towards chemical and Natech risk information disclosure?

This niche in the risk communication literature becomes even smaller when considering the case of Japan. Not surprisingly, risk communication practices surrounding the Fukushima nuclear accident monopolize the scientific interest. Figueroa (2013) approached the topic through anthropological research, and stressed the lack of transparency in the decision-making processes from an administrative perspective—an issue that conflicts with the communities' claims for their right-to-know. Similarly, participatory risk management initiatives where policy-makers, stakeholders, and local community representatives can cooperatively discuss and build consensus about risk-related issues were inadequate. More recently, Murakami and Tsubokura (2017) discussed the influences and justifications of risk communication, and how such systems are designed in the post-accident Fukushima era. Their nudge theory approach discovered "ethically unjustifiable" risk communication practices that should reevaluate the relationship between citizens and the government.

2.4 Why STOPS?

There have been several approaches in the health and risk communication literature that attempt to understand and predict individuals' information-seeking behavior—for a review see Sheppard et al. (2012). Examples include the Risk Information Seeking and Processing (RISP) model (Griffin et al. 1999), the Theory of Planned Behavior (TPB) (Ajzen 1991), and the Extended Parallel Process Model (EPPM) (Witte 1992). Common motifs in such theories are that individuals' risk perceptions and affects drive information seeking, and that self-efficacy defines behavioral change and information processing. However, what seems to be still lacking is a methodology to examine citizen communicative behavior concerning disaster risk information. From a communications perspective, community appetite for chemical risk information can be distilled to understanding how citizens communicate about the risk itself and the associated information disclosure issue. Diverging from the narrative of perceived hazard characteristics as the key drivers of information-seeking behavior, this research ventures to assess the perceived problem of chemical risk information deficiency by looking at how individuals communicate through acquiring, selecting, and transmitting information about Natech accident risk.

In an attempt to identify, empower, and engage with the affective part of citizens exposed to chemical and Natech accident risk, a theoretical framework beyond the perception and social psychology of risk is employed—an approach that focuses on "communicative actors." Communicative actors are not only expected to diligently search for, review, and synthesize any available information pertaining to the issue, but are also more likely to reciprocate the efforts and engage in two-way communication (Grunig and Kim 2017). In this respect, by focusing on communicatively active publics, risk communicators have an opportunity to learn more about the communities' demands, fears, and (mis-)perceptions concerning the risk in order to effectively balance the interests of the communicating parties (Grunig 2018). Such audience-oriented risk communication approaches that are based on analyzing and segmenting audiences can assist organizations and risk managers in drafting effective and targeted communication strategies where needed (Fraustino and Liu 2017). Adhering to a participatory risk management approach that emphasizes citizen engagement, it is imperative to introduce an interpretative framework to identify such legitimate actors within communities and appreciate their communicative behavior. The STOPS offered this conceptual background, as it explains such exigent publics and predicts who will communicate actively (Kim and Grunig 2011).

Through the interpretative framework of STOPS emphasis is placed on understanding why and how problem solving begins, and what communicative characteristics the solver exhibits (Kim and Krishna 2014). In terms of risk communication, this approach provides valuable insight into how communities actually perceive and process problematic situations. Furthermore, according to STOPS the public opinion concerning the issue at hand is expressed by the communicative behavior individuals assert in order to solve the problematic situation. This is a fundamental argument for the purposes of this research. Applying this reasoning permits an in-depth analysis of the citizens' interpretation of the problematic situation, which arises from the lack of disclosed Natech risk information. A community's appetite for risk information can be (in-)directly gauged in this way.

The STOPS was initially proposed as a generalized theory of problem solving, and has been primarily applied in the public relations and organization communication fields. Researchers employed the theory to evaluate government-public relationship quality in regard to urban issues (Lovari et al. 2012) and in the context of post-incident crisis communication (Chon 2019). In organization communications, STOPS helped researchers study government-citizen communication strategies (Lee 2016) and social media activism concerning contentious issues (Chon and Park 2020), interpret issues of sociological public diplomacy (Kim and Ni 2011), as well as describe communicative behaviors of hot-issue publics active on media issues in a sociopolitical context (Kim et al. 2012; Chen et al. 2017). It is noteworthy that there has been only one application of STOPS so far in the field of crisis communication. Liu et al. (2019) employed the STOPS model to understand the communicative behavior of publics, focusing on how individuals communicate immediately prior to an event and how they respond to tornado warnings. To the best of our knowledge, STOPS has not been applied for disaster risk management and communication issues covering the preparedness phase for any hazard type, let alone concerning the risk of chemical and Natech accidents. It should be noted that STOPS has been successfully applied in a plethora of sociocultural settings. These include Western cultures, such as the US (Kim and Grunig 2011; Chon and Park 2020) and Italy (Lovari et al. 2012), but also cultures with Asian characteristics, such as South Korea (Kim et al. 2012; Lee 2016; Chon 2019) and Taiwan (Chen et al. 2017). However, STOPS has not been tested yet against the unique sociocultural context of Japan.

2.5 Situational Theory of Problem Solving (STOPS)

The STOPS asserts that communication is purposeful. It is not the by-product of problem solving communicative action, but rather its manifestation. The central notion is that when individuals commit themselves to problem resolution, the more they search to acquire information concerning the solution of the issue, the more rigorously they select such information, and the more actively they transmit it to others (Kim and Grunig 2011). Three main parts can be distinguished in the conceptual model (Fig. 1): the perceptual and cognitive frame, the situational motivation, and the communicative behavior.

The perceptual and cognitive frame is defined by four situational antecedents, that is, three perceptive variables and one cognitive one (Kim and Grunig 2011; Kim and Krishna 2014).

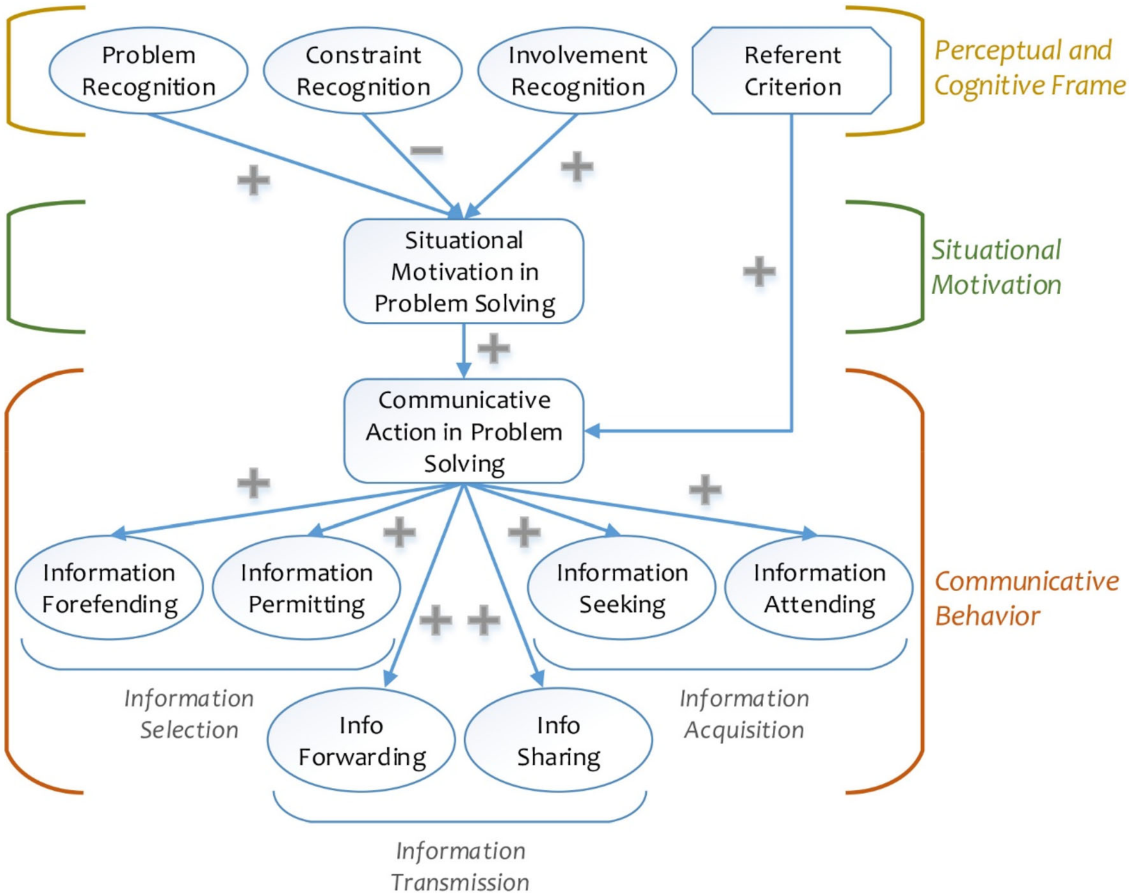

Fig. 1 Conceptualization of the Situational Theory of Problem Solving (STOPS). Source Based on Kim and Krishna (2014).

Problem Recognition (*PR*) A problematic situation presents itself through the perceived discrepancy between an individual's expectations and their experiential reality. This realization that something is missing and that there is no immediately applicable solution to the situation is defined as problem recognition.

Involvement Recognition (*IR*) Involvement recognition is conceptualized as the perceived connection between individuals and the problematic situation.

Constraint Recognition (*CR*) Constraint recognition can be understood as a measure of the perceived obstacles that prevent individuals from taking action towards resolving the problematic situation.

Referent Criterion (*RC*) The referent criterion is the cognitive factor of the situational antecedents. It is defined as any prior knowledge, experiences, expectations, and subjective judgmental rules an individual activates or improvises in the cognitive process to solve current problems.

Situational motivation acts as the mediator between the situational antecedents (that is, problem, involvement, and constraint recognition) and the communicative action.

Situational Motivation in Problem Solving (*SM*) Kim and Grunig (2011, p. 132) identified this variable as a measure of "the extent to which a person stops to think about, is curious about, or wants more understanding of a problem." Subsequently, situational motivation, along with the influence of activated or improvised referent criteria, encourages the engagement in communicative action (Chen et al. 2017).

The final part of the STOPS model describes individuals' communicative behavior.

Communicative Action in Problem Solving (*CAPS*) CAPS is conceptualized as a second-order composite factor that incorporates three dimensions of communicative behavior individuals adopt when attempting to resolve an issue—information acquisition, selection, and transmission (Kim and Grunig 2011; Kim and Krishna 2014). Each of these dimensions is characterized by two components: one passive and one active expression.

Information Acquisition: *Information Attending* (*IAtt*) and *Information Seeking* (*ISek*) Attending describes the effortless discovery of messages, while seeking describes the planned scanning of the individual's environment for messages related to the specific problem.

Information Selection: *Information Permitting* (*IPrm*) and *Information Forefending* (*IFrf*) Permitting means a passive acceptance of messages from various sources, whereas forefending is the specific and systematic selection of information relevant to an individual's subjective opinion on a suitable solution.

Information Transmission: *Information Sharing* (*IShr*) and *Information Forwarding* (*IFwd*) Sharing refers to a reactive stance concerning information sharing only when asked to, while forwarding is a proactive form of information communication of perception and possible solutions. It is important to note that passive problem solvers are likely to engage in only passive communicative actions, while active problem solvers tend to display both active and passive communicative behaviors. Therefore, CAPS assumes a positive association with all involved actions.

Translating STOPS into the context of chemical and Natech risk communication, citizens evaluate the presented problematic situation stemming from the information deficiency, their personal connection with the issue, and the barriers that limit their ability to take action in resolving it. According to their knowledge, subjective judgmental rules (for example, moral or cultural issues), and expectations about how chemical and Natech risk information should be handled, their situational motivation impels them to engage in communicative action. Interestingly, the potential Natech accident risk local residents are imperceptibly subject to because they live near industrial facilities in areas exposed to natural hazards, sets the stage of the initial problematic situation. However, this study enquires about the cognitive meta-problem deriving from the lack of publicly available information concerning this problematic situation (perceptual problem). According to Kim and Grunig (2011), this cognitive meta-problem comes into existence due to the absence of a ready-made solution for the perceptual problem. Although the perception about this meta-problem is not the same as the Natech risk perception, the connection between the two can be logically inferred. The higher the concern about a potential Natech risk, the larger the problem of information deficiency becomes.

The STOPS posits that the general public is not homogeneous with respect to the communicative behavior they adopt towards a certain problem. Within what is conceived as the "general public," individuals are actually divided into four main categories—nonpublic, latent, aware, and active/activist publics (Kim and Grunig 2011). Each type exemplifies a different communicative behavior based on their interest—or lack thereof—to resolve the issue of concern. Nonpublic publics consist of individuals who perceive no initial problematic situation, and therefore neither the need for involvement nor constraints; latent publics perceive a problem through its consequences, but have yet to detect it; aware publics have recognized the issue, but have not taken any action to resolve it; and active/activist publics have started coordinating their actions on solving the problem, either as individuals or in a more collective fashion (Kim 2011; Kim and Ni 2013).

3 Methodology

In this section, we elaborate on the research aim and introduce the hypotheses of the study considering the concepts presented earlier. Moreover, we discuss matters pertaining to data collection, such as the selected study areas and the questionnaire design.

3.1 Research Aim

This research project ventures to investigate whether residents near Osaka Bay want Natech risk information to be disclosed, as well as to understand their communicative behavior patterns and perceived challenges towards this issue. Considering the threat from a potential tsunami induced by the anticipated Nankai megathrust earthquake (Fujiyama 2013) and the high concentration of chemical facilities in the region, Natech accident risk is certainly not negligible. As an exploratory study on the subject of citizen motivation for risk communication, the intention is to shed light on the reasons behind the communities' attitude towards chemical and Natech risk communication in Japan, and help develop hypotheses for future research. The main research question is: What is the communicative behavior of citizens towards chemical and Natech risk information disclosure in Japan? Within the STOPS framework, this study explores the situational antecedents of Communicative Action in Problem Solving (CAPS) to understand citizen motivation to communicate about the issue, and looks at CAPS elements in order to analyze citizens' communicative behavior. Considering the methodological novelty this research presents by introducing STOPS in the unique sociocultural context of Japan and in the field of Natech risk communication, a secondary research aim is to apply for the first time and evaluate the interpretative power of this methodological framework in explaining publics' communicative behaviors pertaining to chemical risk communication issues in Japan.

The principal hypothesis that drives this research is that individuals are highly motivated to solve the problem of Natech information deficiency, and that there is appetite for risk communication and information disclosure. Examining this postulate through the prism of STOPS, there are four core conditions to be met, starting with citizens acknowledging the absence of chemical and Natech information as a problematic situation that involves them personally, while there are significant constraints limiting their actions. The following factors influence individuals' situational motivation in resolving the problem:

(1) Problem Recognition has a positive effect on Situational Motivation (*H1*);
(2) Involvement Recognition has a positive effect on Situational Motivation (*H2*);
(3) Constraint Recognition has a negative effect on Situational Motivation (*H3*);
(4) Individuals are hypothesized to communicate in order to solve the presented problem, and therefore, their situational motivation drives their communicative activeness. Situational Motivation has a positive effect on Communicative Action in Problem Solving (*H4*).

A set of auxiliary hypotheses (H_a) are tested as well in order to evaluate the performance of STOPS within the context of chemical risk communication and in Japan. Assumptions that describe the relationships between the rest of the variables within the model were defined following the seminal work of Kim and Grunig (2011). Activated or improvised referent criteria are expected to increase communicative activeness in resolving the issue of Natech risk information deficiency. An increase in individuals' communicative activeness is associated with a rise in both the active and passive components of each of the three dimensions—information acquisition, selection, and transmission. Thus, Referent Criterion has a positive effect on Communicative Action in Problem Solving (H_a1); CAPS has a positive effect on Information Forefending (H_a2_a) and Information Permitting (H_a2_b); CAPS has a positive effect on Information Forwarding (H_a3_a) and Information Sharing (H_a3_b); and CAPS has a positive effect on Information Seeking (H_a4_a) and Information Attending (H_a4_b).

3.2 Data Collection

In an attempt to analyze the actual situation in Japan in terms of appetite for Natech risk communication and information disclosure from the perspective of the communities, the citizens' opinions were measured directly through a household questionnaire survey. Participants were asked to indicate their level of agreement with statements that reflected their situational perception and the communication actions they engage in concerning this issue. A 7-point Likert-type scale ranging from 1 = "Strongly Disagree" to 7 = "Strongly Agree" was used to code the responses. As a rule, three items per STOPS variable were included. The wording of the questions was based on measurement items tested and validated in previous applications of STOPS (Kim et al. 2012; Chen et al. 2017) with minor adjustments when necessary. The questionnaire was reviewed by a panel of 30 experts specializing in disaster risk management before its translation to Japanese and deployment.

In contrast to an online survey, a mail survey was chosen so as to control for the location of respondents and account for the "distance-decay" effect. This principle describes the progressive discount of individuals' concerns about the risk the farther they perceive they are from its source (Venables et al. 2012; O'Neill et al. 2016). Yu et al. (2017) recently confirmed the distance-decay effect on household risk perception about Natech accidents in Japan. In an attempt to focus on perceptions of citizens who are actually under immediate risk from a chemical accident, households within a 2 km radius from industrial installations were targeted primarily. The distance was chosen taking as an example the 2 km radius evacuation order around the installations during the JX oil refinery Natech incident caused by the Great East Japan Earthquake in 2011 (WHO 2018).

The study focused on two large industrial parks with clustered facilities that handle hazardous materials, located in the areas of Higashinada (Kobe) and Sakai-Senboku (Osaka), on the north and southeast banks of Osaka Bay, respectively. The tsunami wave height from a potential Nankai Trough earthquake is estimated to reach 3 m across Osaka Bay (Japan Meteorological Agency 2019), posing a direct threat to industrial facilities located along the coastline (Nishino and Takagi 2020). Residential areas predominantly next to the respective waterfronts of Higashinada and Sakai-Senboku and within 2 km from chemical and oil storage facilities were selected from both regions, so as to examine the situation across the bay in a more comprehensive way.

A total of 2630 self-administered questionnaires were distributed to all registered postal addresses (envelopes were not personally addressed to anyone) within selected city districts using postal mail services. The anonymity of the respondents was guaranteed through the use of this "Town Mail" delivery system, while participation was completely voluntary and without a reward incentive. A brief introduction explained what Natech accidents are to participants and outlined the purpose of the questionnaire, that is, to understand how people communicate about the disclosure of information concerning possible Natech accidents in the industrial parks along the coast of Osaka Bay. No additional information about potential Natech accident scenarios was provided in order to avoid influencing participants' perceptions by alarming them with issues such as potential adverse health effects or possible accident sources from nearby facilities. Questions pertaining to Natech risk were presented separately from those about the issue of Natech risk information not being disclosed, while the distinction between the different parts of the survey was clearly marked. Data collection was carried out from 26 January to 8 March 2018. 330 households responded to the survey (12.47% response rate), yielding a total of 327 replies after discarding 2 unanswered questionnaires and 1 unengaged respondent (that is, answered "7" throughout the questionnaire). In comparison, previous studies with similar questionnaire distribution methods yielded a slightly higher rate (14.3%) in Japan (Kotani and Yokomatsu 2019) and a lower rate (8.3%) in the United Kingdom (Eiser et al. 2009).

4 Analysis Methods

In this particular study, structural equation modeling (SEM) was employed for confirmatory purposes, in order to evaluate the STOPS model in the field of chemical and Natech risk communication and in the context of Japan. No alternative models or configurations were proposed and tested. Furthermore, IBM's SPSS and Amos software packages versions 25 (both) were utilized for the analysis, employing maximum likelihood as the estimation method. A two-step SEM approach was adopted (Kline 2011). The first phase involved testing and determining the best items for each latent construct through confirmatory factor analysis. Low factor scores and/or largely insignificant loadings of observed variables on the latent constructs were the criteria according to which items were dropped from the model with the aim of identifying robust, valid, and reliable item configurations. Factor loadings represent the correlation between the original measured items and their respective latent variable, with higher loadings meaning the item is representative of the latent construct. Squared factor loadings indicate what percentage of the variance the respective latent construct explains in an original variable. In the next step, the measurement model was defined. Error covariances were introduced where necessary based on Lagrange Multipliers—but always respectful to the original theoretical reasoning of STOPS. Although the initial sample size is adequate for SEM ($N > 200$), the bootstrapping method with a total of 2000 random resampling iterations was applied complementary to further enhance the statistical robustness of the final model results. The approach of Hu and Bentler (1999) for combined model validity criteria was followed considering several commonly used indices—the Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), and the Standardized Root Mean square Residual (SRMR). The full latent model of the original STOPS conceptualization was used for hypothesis testing and relationship interpretation, and only after model fit indices were deemed satisfactory.

This study followed closely the public segmentation method of summation introduced by Kim (2011). The summation method uses the midpoint of the item scale to recode effectively the situational perception characteristics as "High" = 1 and "Low" = 0, based on the mean scores from the items of each composite variable. The average score for problem, involvement, and constraint recognition was calculated based on the respective questionnaire items, and then was recoded into a dichotomous variable. In this study, the midpoint of the 7-point scale is 4. Therefore, individuals whose response averaged lower than or equal to 4 were coded as "Low" (= 0) for that particular variable. Conversely, if their answer was 5 or higher, they were coded as "High" (= 1). Subsequent summation of the respective recoded characteristics provided the value based on which the classification was conducted: nonpublic = 0, latent publics = 1, aware publics = 2, and active/activist publics = 3.

The dataset with the 327 registered responses passed Little's MCAR test, indicating that values are missing completely at random and therefore list-wise deletion was warranted (Hair et al. 2010). Data cleaning resulted in 317 responses, by dropping 10 respondents whose questionnaire fill-out rate did not reach 90%. The remaining responses were tried again using Little's MCAR test, justifying further data imputation. Remaining missing data were imputed with the respective variable median. This technique is not expected to alter the variable mean (Hair et al. 2010), since the percentage of missing information per variable did not exceed 2.3% (suggested threshold 10%).

Finally, the demographic profile of the 317 respondents is summarized here. The sample consisted of respondents from all age groups, ranging from "younger than 19" to "older than 75," with an average of 60.3 years old (median = 60−74). Most of the respondents had completed high school education (35.7%) and attained a bachelor degree (33.4%). Of the rest, 14.8% had completed a vocational school and 8.5% held Masters or PhD degrees, while 2.2% had completed only elementary education (with the remainder opting not to identify). The median annual household income was below JPY 3,000,000 (about USD 26,000). The mean household size was 2.42 persons with most households consisting of 2 individuals.

5 Results

Proceeding to the model's validity, the latent factors' composite reliability was examined through the estimated Construct Reliability index and Cronbach's α, while the Average Value Extracted was also taken into account (Table 1). All composite variables achieved very high

Table 1 Construct validity measures

Variable	Construct reliability (CR)	Average value extracted (AVE)	Cronbach's α
PR	0.882	0.714	0.877
IR	0.908	0.769	0.898
CR	***0.412***	***0.261***	***0.407***
RC	0.820	0.695	0.819
SM	0.838	0.635	0.826
IFrf	0.795	0.568	0.789
IPrm	0.789	0.569	0.763
IFwd	0.737	***0.483***†	0.737
IShr	0.878	0.707	0.876
ISek	0.860	0.755	0.860
IAtt	0.850	0.655	0.839
CAPS	0.912	0.640	–‡
Criteria	**> 0.70**	**> 0.50**	**> 0.60**

PR problem recognition, *IR* involvement recognition, *CR* constraint recognition, *RC* referent criterion, *SM* situational motivation, *IFrf* information forefending, *IShr* information sharing, *IFwd* information forwarding, *ISek* information seeking, *IAtt* information attending, *IPrm* information permitting, *CAPS* communicative action in problem solving

Cells with BoldItalic text indicate values below respective thresholds. Threshold criteria (cells with Bold text) based on Fornell and Larcker (1981).

†According to Malhotra and Dash (2011, p. 702) AVE is often too strict of a measure, and reliability can be sufficiently established through CR alone.

‡CAPS constitutes a second order latent variable, and as such is not derived by observed questionnaire items from which Cronbach's *a* can be computed.

construct reliability scores (that is, > 0.74 for both indices), except for Constraint Recognition, which exhibited very low scores (that is, $CR = 0.41$ and $\alpha = 0.26$). Given that there was already an item removed from this variable, no further remedies were available. The standardized estimates of the factor and item loadings incorporated in the finalized model are presented in Table 2, indicating an overall satisfactory representation of the latent constructs.

Concerning the model's goodness-of-fit to the data, the joint criteria approach suggested by Hu and Bentler (1999) states that an empirical model is deemed robust enough if it achieves either CFI ≥ 0.96 and SRMR ≤ 0.10 or RMSEA ≤ 0.06 and SRMR ≤ 0.10. The STOPS model satisfied the latter thresholds (Fig. 2), and thus the structural model achieved a satisfactory model fit, which warranted further interpretation of the corresponding causal models.

The causal structural model for the STOPS variables was used to test hypotheses *H1* through *H4*. Following the STOPS narrative, the more individuals recognized a problematic situation regarding the Natech risk information deficiency (PR), the more motivated they became (SM) to do something about the issue (*H1*). This could not be confirmed due to the very low standardized estimate (*B*) along with its statistical insignificance ($B = 0.07$, n.s.). The other two situational variables followed the hypothesized patterns. The more residents perceived the Natech risk information deficiency affected their lives (IR), the higher their motivation (SM) was (*H2*). A statistically significant and relatively strong coefficient supported this ($B = 0.33$, $p < 0.05$). Additionally, the larger their perceived constraints in doing something about the issue (CR), the more their motivation (SM) diminished (*H3*). Constraint Recognition actually exhibited a very strong negative influence on SM ($B = -0.42$, $p < 0.001$), although these results should be treated with caution due to the construct's relatively poor reliability, as previously mentioned. Lastly, residents were expected to channel their situational motivation (SM) to solving the problem by intensifying their communicative actions (CAPS) (*H4*). Situational Motivation proved to have a very strong impact on CAPS ($B = 0.77$, $p < 0.001$).

Complementary, one auxiliary hypothesis about the Referent Criterion (RC) (H_a1) and six about the CAPS variables (H_a2 through to H_a4) were tested in order to validate STOPS, all of which were confirmed with large and statistically significant estimates. Activated RC enhanced individuals' CAPS for the Natech risk information deficiency issue (H_a1) ($B = 0.30$, $p < 0.001$). All aspects of communicative behavior were positively affected by the residents' professed CAPS—specifically, information forefending (H_a2_a) ($B = 0.74$, $p < 0.001$), information permitting (H_a2_b) ($B = 0.86$, $p < 0.001$),

Table 2 Factor and item loadings for dependent and independent variables

Second-order factor	First-order factor loading	First-order factor	Item loading*	Questionnaire item
		Problem recognition	0.780	PR1
			0.823	PR2
			0.840	PR3
		Involvement recognition	0.885	IR1
			0.833	IR2
			0.822	IR3
		Constraint recognition	0.455	CR1
			0.586	CR2
		Referent criterion	0.880	RC1
			0.783	RC2
		Situational motivation in problem solving	0.843	SM1
			0.749	SM2
			0.848	SM3
Communicative Action in Problem Solving	0.737	Information forefending	0.767	IFrf1
			0.663	IFrf2
			0.838	IFrf3
	0.863	Information permitting	0.784	IPrm1
			0.834	IPrm2
			0.444	IPrm3
	0.967	Information forwarding	0.735	IFwd1
			0.659	IFwd2
			0.702	IFwd3
	0.790	Information sharing	0.881	IShr1
			0.778	IShr2
			0.853	IShr3
	0.680	Information seeking	0.847	ISek1
			0.883	ISek2
	0.675	Information attending	0.714	IAtt1
			0.817	IAtt2
			0.878	IAtt3

N = 317

*Based on best measurement items.

information forwarding (H_a3_a) ($B = 0.97$, $p < 0.001$), information sharing (H_a3_b) ($B = 0.79$, $p < 0.001$), information seeking (H_a4_a) ($B = 0.68$, $p < 0.001$), and information attending (H_a4_b) ($B = 0.67$, $p < 0.001$). Overall, CAPS, as a second-order latent variable, performed satisfactorily as indicated by the construct reliability results (see Table 1) and the respective factor loadings of the six communicative actions (see Table 2).

Finally, as far as the abovementioned predictors' explanatory potency is concerned, the STOPS model exhibited exceptional results. In the case of the residents' situational motivation to resolve the problem, the three situational perception variables explained almost 60% of the observed variance ($R^2 = 0.59$). Explanatory power was even higher in the case of CAPS, exceeding 80% ($R^2 = 0.84$) just from the influence of SM and RC. Similarly, interpretative power ranged from a notable 46% ($R^2 = 0.46$) to a staggering 94% ($R^2 = 0.94$) for the respective communicative actions.

Concerning the public segmentation (Fig. 3), out of the 317 survey respondents only five (1.58%) did not seem to perceive the presented situation stemming from the absence of publicly available Natech risk information as a problem, comprising a nonpublic group. Thirty respondents (9.46%), a latent public group, seemed to perceive the Natech risk information deficiency as a problem because of

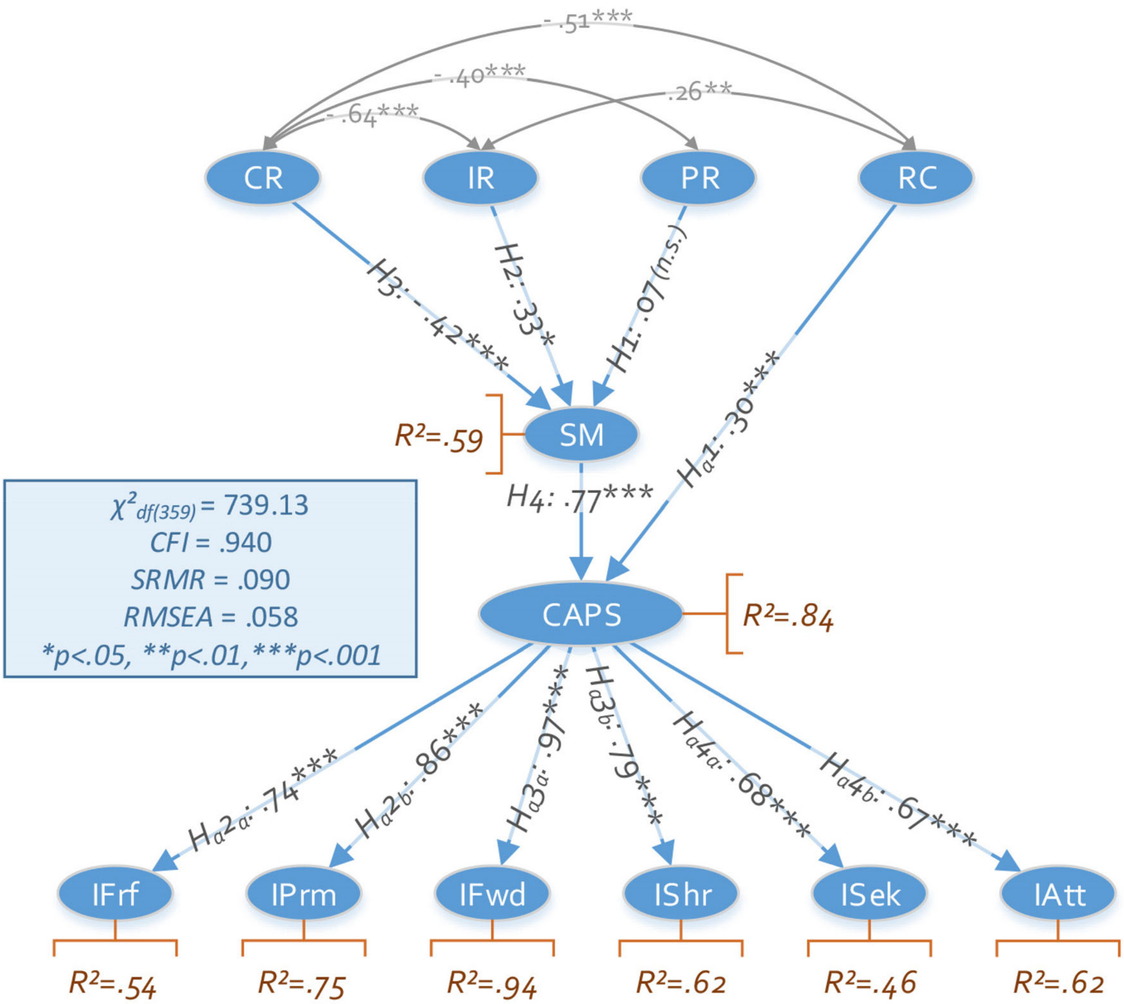

Fig. 2 Summary model results from the Situational Theory of Problem Solving (STOPS) structural model. *CR* constraint recognition; *IR* involvement recognition; *PR* problem recognition; *RC* referent criterion; *SM* situational motivation; *CAPS* communicative action in problem solving; *IFrf* information forefending; *IPrm* information permitting; *IFwd* information forwarding; *IShr* information sharing; *ISek* information seeking; *IAtt* information attending. Indices: *CFI* Comparative Fit Index; *SRMR* standardized root mean square residual; *RMSEA* root mean square error of approximation

its consequences in their lives, though they might not have fully acknowledged it yet. More than half of the sample belonged to an aware public. These 178 respondents (56.15%) perceived the Natech risk information deficiency as a significant issue that motivates them to do something about resolving it, though they had not taken any actions yet. Finally, 104 respondents (32.81%) demonstrated high problem and involvement recognition, while finding only obstacles they can overcome relatively easily, forming an active/activist group.

Residents' communicative behavior can be further analyzed using these four types of publics as a basis and calculating the mean values for each (Fig. 4). Confirming the narrative of STOPS, non- and latent publics, categories with lower situational perceptions, scored correspondingly lower on all communicative actions. As expected, communicative activeness increases in aware and active/activist groups. Generally, the non- and latent publics scored lower than the midpoint, while their patterns almost coincided across different actions, with the largest difference among them in information attending. Interestingly, the nonpublic group exhibited higher communicative activeness compared to the latent category in information selection and transmission. This result is probably related to the nature of the problem. Nearly half of the latent public were individuals who recorded a high constraint recognition, which as the model revealed exerts substantial negative influence on situational motivation. It may well be that the first aspect individuals perceive about the Natech risk information deficiency is the difficulty in selecting relevant information for this complex issue and transmitting it to others, regardless of their attitude towards learning more about it and acquiring information. Similarly, the active/activist public scored lower than the aware public in all

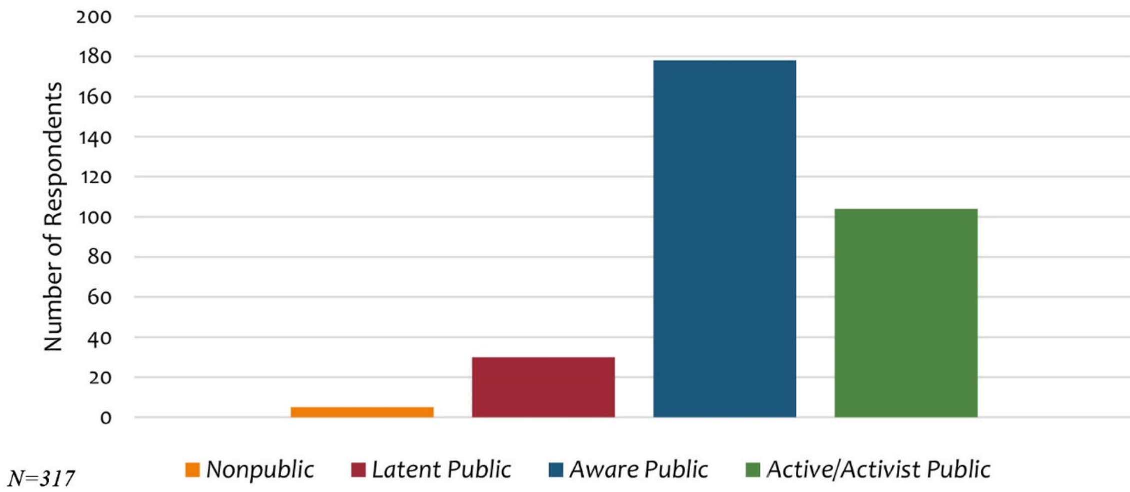

Fig. 3 Public segmentation for the Natech risk information deficiency problem

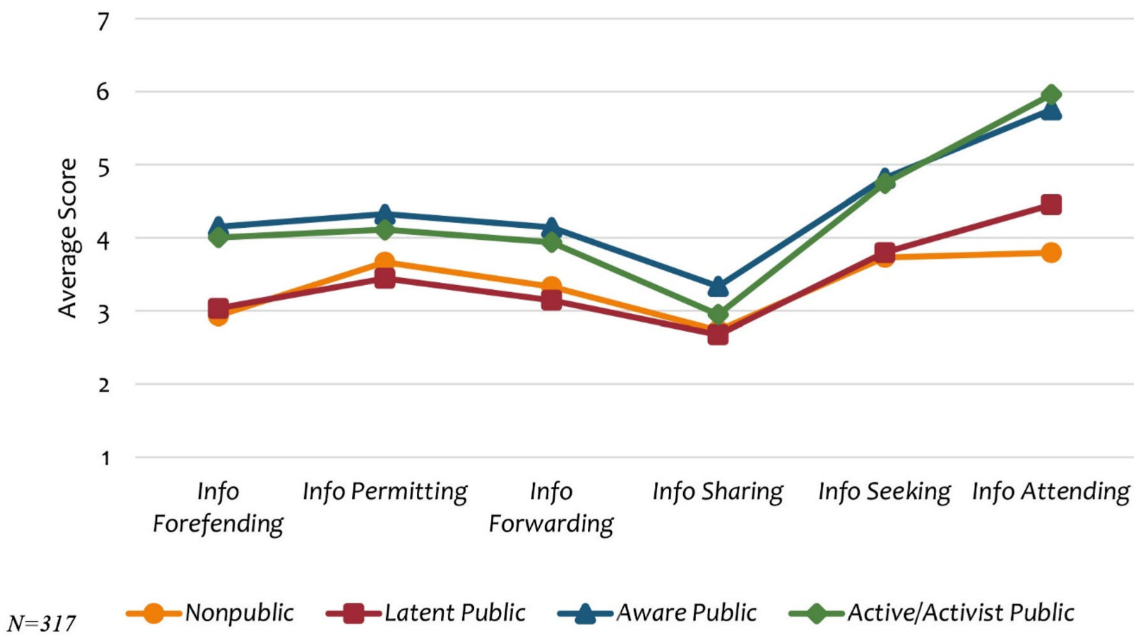

Fig. 4 Communicative actions of different publics

communicative aspects, except for attending information about the Natech risk information deficiency. According to the situational theory, as situational motivation increases, information acquisition peaks first, followed by information selection and transmission, respectively. This may indicate that the active/activist public for this issue has not yet transitioned completely out of the inquiring stage during which information acquisition is important for opinion formation regarding the solution. Although they have acknowledged the problem and have started to engage in communicative action, they still appear to be at an initial stage. Hence the minor differences from the aware public. It is worth noting that information sharing, albeit a passive component, consistently scored the lowest across all publics. Its counterpart, information forwarding, showed the second lowest values in aware and active/activist publics and third lowest in latent and nonpublic publics, indicating that information transmission about the Natech risk communication problem is suffering overall.

Five questions regarding the Natech accident risk were additionally included in the survey, in order to better understand residents' perceptions of the underlying accident threat itself. Figure 5 shows the percentage of respondents per level of agreement for each statement.[4]

[4] The original sample of 327 responses was used for this descriptive statistical analysis.

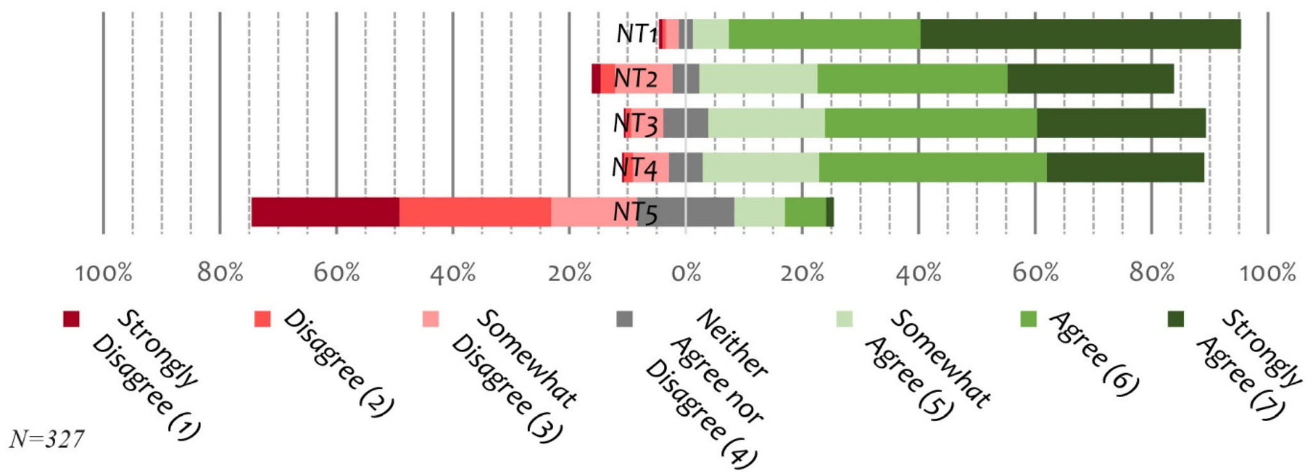

Fig. 5 Responses on chemical and Natech accident risk. *NT1* Natech accidents are an important problem, *NT2* Natech accidents concern local residents, *NT3* Natech accidents are likely to occur, *NT4* Natech accidents could impact local residents, *NT5* Residents know how to respond to potential Natech accidents.

Households strongly expressed their concern about facing a potential chemical accident triggered by a natural hazard generally (*NT1*: $\mu = 6.33$), and in their respective places of residence specifically (*NT2*: $\mu = 5.52$). Apart from the perceived probability, residents also evaluated their potential exposure to such an accident as likely (*NT3*: $\mu = 5.72$) with direct consequences for the local community (*NT4*: $\mu = 5.68$). It is noteworthy that the majority of the households admitted their lack of knowledge in responding appropriately during such scenarios (*NT5*: $\mu = 2.75$).

Finally, Age, Education, Household Size and Income were used as controlling factors for the situational factors of the model. All estimated factor loadings of these variables on PR, IR, and CR were relatively small, particularly less than $B = 0.19$, while half of these relationships were not even statistically significant. Estimates about the relationship of age with the situational variables were non-significant, and all connections between constraint recognition and demographics were likewise insignificant. Educational level and household size had a small positive effect on both problem and involvement recognition, while income had a weak inverse relationship with them.

6 Discussion

The synthesis of our results offered some interesting insights about the perceptions and challenges of local residents concerning Natech risk communication in Japan, and also allowed us to evaluate the performance of the employed methodology. Apart from delineating how citizens communicate about Natech risk considering the information deficiency problem, we discuss the implications of this study in terms of chemical risk management and risk communication policies.

6.1 STOPS Evaluation

Considering the theoretical approach, STOPS seems to be a valid framework for measuring and understanding the publics' communicative action in problem solving within the Japanese sociocultural context and for the issue of Natech risk information disclosure. The model was found to be internally consistent (all expected relationships between the variables were supported) and statistically robust in explaining the hypothesized relationships between the variables. The only exception was the weak and statistically insignificant estimate of problem recognition (PR) on situational motivation in problem solving (SM). But even then, the hypothesized direction of the relationship was verified. A probable explanation for this is that chemical—and consequently Natech—accident risk is characterized by high levels of dread in public perceptions (Slovic and Weber 2002; Sheppard et al. 2012). Asking citizens about the perceived severity of a problematic situation that is associated with a dreadful risk is expected to receive increased significance. This argument is reflected in the study sample through the negative skewness and high kurtosis of the corresponding questionnaire items and composite variable (*Skewness* = − 1.19; *Kurtosis* = 1.83). The fact that SEM relies on the analysis of sample variance to infer statistically significant relationships between variables is by no means evidence against the original model conceptualization. It is highly likely that the variation in PR was too small to capture its effects on SM in this way.

Additionally, the viability of the structural model itself has been established under the strictest of measures, the joint criteria approach of Hu and Bentler (1999). Even more impressive, this has been accomplished using a dataset that was not intended to test the theory per se, but rather apply its interpretative framework in order to understand citizens' communicative behavior towards chemical and Natech risk communication. Resource limitations aside, the purpose of this study was to understand the perceptions and challenges of citizens, who are likely to be directly impacted in a chemical and Natech accident, and spatial proximity to industrial installations is a key issue here. Selecting districts near industrial sites in Osaka Bay arguably introduces another bias. Even so, it is interesting to report that the participants' sense of involvement with the problem and being constrained in doing something still varied considerably across respondents. The STOPS performed exceptionally well in explaining large portions of the observations' variance overall, even under such extreme circumstances of "partial" sampling. Finally, it should be mentioned that age, education, household size, and income exhibited no significant influence on the situational perception of this issue. Therefore, the cross-situational impotency of demographic characteristics in comparison to the perceptual variables of STOPS (Kim et al. 2009, 2012) was confirmed in this study.

6.2 Communicative Behavior

This study showed an increased public concern for chemical and Natech risks as predicted from the literature (Slovic and Weber 2002; Sheppard et al. 2012). Households characterized a Natech accident scenario as possible and severe, recognizing potential consequences for their communities. More interesting, however, is the discovery of a notable awareness regarding the perceived meta-problem of information deficiency that stems from this situation. The lack of chemical risk information is acknowledged by local residents as a problematic situation they are concerned about and that affects their personal lives to a certain degree. They admitted their inability to respond in potential Natech accident scenarios due to insufficient information, which is reasonable since the Japanese chemical risk regulatory framework does not require local governments and industrial companies to disclose contingency and emergency response plans to the community.

According to STOPS, situational perception of the problem's significance, the personal connection with it, and the complications that limit one's ability to resolve it drive individual motivation to take communicative action. In this case, the degree to which households perceived constraints was the most influential in shaping this situational motivation for problem solving, followed by involvement recognition. The effect of problem recognition could not be statistically supported, but logically inferred. All of these measures were considerably high. Accordingly, there seems to be a community appetite for more chemical and Natech information disclosure.

Furthermore, high situational motivation seemed to be the leading factor for citizens' communicative activation. Information acquisition is the most active component irrespective of the various publics. This means that citizens search for information pertaining to Natech risk communication in their attempt to comprehend the involved chemical risk, as well as how it is being handled by the authorities, and proceed accordingly (that is, prepare against it or seek reassurance). This reasoning aligns with the arguably passive role of communities in terms of chemical risk management in Japan on account of information deficiency (Mochizuki 2014; Shimizu 2016).

Referent criteria contribute by a smaller amount to communicative activeness. Moreover, information forefending was low, indicating the absence of a strict information selection process according to STOPS (Kim and Krishna 2014). It is likely that individuals do not have already set opinions on how such risk information should circulate or even how chemical risks should be handled. In conjunction with high information acquisition behavior patterns, Natech risk communication can be interpreted as a complicated issue for citizens to comprehend and take a stance on as they are still trying to gather information about it.

Almost nine out of ten respondents belong to either an aware or active/activist public. This distribution describes a state in which the dominant majority of citizens acknowledges to a large extent the significance of the problem. These publics also exhibited the highest communicative activeness, meaning essentially that the largest portion of citizens is actively communicating and seeking information about the chemical and Natech risk. Perhaps this captures the recent surge in citizen activism about chemical and nuclear risk management in Japan described in the literature (Figueroa 2013).

6.3 Policy Implications

This study highlights the opinions of citizens, who are usually at the receiving end of chemical risk communication practices within the Japanese reality. In doing so, the study advocates for meaningful and constructive dialogue among all involved stakeholders and stakeseekers, placing due emphasis on actively engaging local communities in participatory risk management methods. Risk communication is understood as the foundation of participatory risk management, and a community's right-to-know as the cornerstone of risk communication (Baram 1984; Hadden 1989). This study set out to address a vital precondition for cooperation: whether there is community appetite for chemical and Natech risk communication. The STOPS allowed for a structured, in-depth empirical analysis of the citizens' motivation to communicate about this issue, by assessing their communicative behavior, and investigating the determining situational factors of the perceived problem severity, personal connection, and constraint.

In this respect, the findings are significant. Responding citizens around Osaka Bay do have an appetite for more risk communication and information disclosure concerning chemical and Natech accidents. Regulatory reforms aimed at introducing and fostering community right-to-know initiatives may be warranted based on the respondents' eagerness to engage in meaningful communication. Not only did they recognize the problem of information deficiency as significant and in direct connection with their lives, but also explicitly characterized this lack of publicly available chemical risk information as an obstacle that prohibits them from appreciating the real situation. The vast majority of the participants fell under the categories of aware and active/activist publics, indicating that they are increasingly acknowledging this issue of risk information deficiency, while risk perceptions about chemical and Natech accidents were also elevated. Substantial evidence indicated that this increased situational motivation of citizens to do something about this presented discrepancy is being channeled into communicative action, while their efforts intensify in seeking and acquiring information about the problem.

Although the above arguments are not groundbreaking in the sense of challenging established risk communication approaches, for risk managing authorities in Japan they present a convincing case based on empirical evidence to adopt and promote policies targeted at openly sharing information about actual chemical and Natech risks, as the consequent benefits are mutual (OECD 2003; UNISDR 2015). On the one hand, transparency encourages deliberation processes and consensus building for appropriate mitigation measures and promotes understanding and acceptance of technological risks (Aven and Renn 2010). On the other hand, the communities' capacity to cope effectively with a chemical or Natech accident scenario is enhanced by risk communication. Households become adequately informed of the potential hazardous scenarios they might face, as well as the warning systems and contingency plans in place, and therefore can prepare their response actions accordingly (Palenchar 2008).

Policymakers are recommended to pursue, promote, and institutionalize community participation in risk-related decision making for chemical and Natech risks (OECD 2003; UNISDR 2015), starting with designing the regulatory tools for citizens to access such information. Regulatory frameworks, such as the EPCRA, the Seveso Directives, or even the more recent South Korean Chemicals Control Act, can serve as inspirational examples on how to initially address technological risk management and adjust it to the Japanese reality. Considering the citizens' perceived problem, involvement, and constraint recognition pertaining to the lack of risk information, the challenges arise from the exclusion of communities from the chemical risk management processes in the first place. Risk managers could aim at actively engaging citizens in order to address the associated concerns about the management of the chemical and Natech risk, thus reducing the perceived severity of risk information deficiency. Participatory approaches in risk management advocate for an inclusive multiactor process that invites and involves representatives from the spheres of government, business, and community. Methods worth exploring in this direction entail, for example, citizen forums, negotiated rule-making exercises, and mediation or advisory committees (Aven and Renn 2010).

Another advantage STOPS offers when drafting risk communication strategies is public segmentation. This approach can be a valuable aid for effective strategic risk communication in developing tailored risk communication strategies and efficiently allocating resources to accommodate various priorities (Kim and Ni 2013). The STOPS allows risk communicators to break down the broader target audience into finer and more manageable elements in terms of resources or action potential. Risk managers can then delineate the profile of citizens who comprise nonpublic, latent, aware, and active/activist groups with respect to various characteristics of interest (for example, sociodemographic features), in order to draft communication strategies that effectively target, approach, and engage such publics in the risk management processes and address their (mis-)perceptions and concerns about the risk.

7 Study Limitations

Certain methodological issues emerged during the analysis. First, irrespective of the statistical assessment of the model's ability to explain the variance observed in the dataset, there may be influencing factors that were excluded from the analysis. This study acknowledges that the original conceptualization and application of STOPS in the given context might have omitted important factors. Further studies may expand the model by borrowing theoretical constructs from other approaches or introducing new explanatory variables. The empirical validation of the model used in this study does not suggest confirmed causal relationships among the variables under investigation. This framework constitutes an approach to comprehend the citizens' perceptions about the problem of Natech risk information deficiency, not a depiction of the actual multifaceted situation.

Then, there were issues with the observed variables. For instance, the latent variable of constraint recognition never achieved the required construct reliability thresholds, even after dropping the most troublesome item. It was retained in the model because this is an exploratory study that uses the STOPS model for the first time in order to understand Natech risk communication in Japan. Nonetheless, this limitation may stem from the measurement tool, and more precisely the item phrasing, rather than the conceptual framework.

Moreover, the reply rate of 12.5% is generally low to be considered representative of the target population. However, when considering that no incentives were provided to participants who responded freely to an anonymous survey, this is somewhat understandable. Although all households within the designated districts were contacted using the postal distribution system, the lack of incentives may have introduced a self-selection bias towards residents with greater interest in the topic. Different data collection strategies may be employed in future surveys to address this issue. A stratified random sampling method based on sociodemographic criteria (for example, gender, age, education, income, and so forth) would be more appropriate when pursuing a more accurate representation of the broader population in the sample. However, in that case geographical restrictions may have to be reassessed. In view of keeping the required anonymity involved in data collection while targeting households near industrial parks, providing reward incentives for respondents is also expected to increase the reply rate. But because very few studies have focused on chemical—and particularly Natech—risk communication in Japan, the findings are important. The intention of this study was not to produce generalizable results for the whole of Japan, but rather to focus on the risk perceptions and communicative behavior of residents around industrial parks in Osaka Bay.

8 Conclusion

This study focused on appreciating the public perceptions concerning the problem of chemical risk information deficiency by conducting a household survey in the prominent industrialized region of Osaka Bay, Japan, and investigating the findings through the interpretative framework of STOPS. The findings emphasize a notable citizen awareness concerning the perceived problem of Natech risk information deficiency, accompanied by high motivation to communicate about it. More importantly, an analysis of citizens' communicative behavior showed increased information acquisition efforts. Citizens actively seek out chemical and Natech risk information in an attempt to better understand this convoluted hazard. The practical implications for policymakers from this clear community appetite for information entail regulatory reforms introducing chemical risk information disclosure and encouraging citizen engagement.

Considering directions for further research, chemical and Natech risk communication can be a fertile ground. Japan is not the first and certainly not the last country that faces risk communication challenges pertaining to community right-to-know and information disclosure. By taking on this new wave of participatory, bottom-up approaches in risk management, future researchers are encouraged to explore risk management issues from the perspective of communities. Since risk communication is the vital element, perhaps public relations approaches similar to this deserve as much of a chance. More qualitative research approaches may help to disentangle the issue of Natech risk communication and information disclosure, especially when attempting to clarify and analyze its complexity from a lay public and community perspective.

This study did not consider the sources or the channels of risk communication and what effect they may have on the public's perceptions and communicative behavior. Future studies may investigate how individuals seek out and exchange information about Natech risk and whether different communication channels affect their behavior. Further research to expand our understanding on how Natech risk information is processed and what the motivating factors are that lead to preparedness and protective actions is equally important from a risk reduction standpoint. Future studies can also examine whether foreign residents and tourists have different opinions concerning Natech risk information disclosure, considering their diverse cultural backgrounds and potential communication difficulties. Foreigners were not the focus of this survey (only 2 out of the 327 respondents) and thus were vastly underrepresented. Going forward, further research is required to understand in-depth all stakeholders' views about Natech risk and address effectively their concerns through risk communication.

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