Comprehending and Acting on Pandemic Health Risk Information Differently: A Qualitative Study Using the Mental Models' Approach

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Abstract

Background

A worldwide pandemic of a new and unknown virus is characterised by scientific uncertainty. Yet, health authorities still need to communicate complex health risk information to the public – despite this uncertainty. The mental models approach to risk communication describes how people perceive and make decisions regarding complex risks, with the aim of identifying decision-relevant information that can be targeted in risk communication interventions. This study used COVID-19 as a case to explore how people make sense of scientific information and apply it to their lives and behaviour using the concept of *mental models*.

Methods

This qualitative study included 15 male and female participants of different ages and from different geographical regions in Norway, occupational areas and with different education levels. The participants were interviewed individually, and the interview data analysed via directed content analysis, with predetermined themes and codes derived from the Norwegian Institute of Public Health's official website. Materials in the interview data not represented by deductive codes were coded inductively. The participants' perceptions and behaviours related to health risk information were analysed across three themes: virus transmission, exposure to risk and consequences of COVID-19.

Results

The results imply that people put different meanings to the medical and scientific words used by experts to explain the pandemic, e.g. virus transmission and the reproduction number. And while some people expressed the need to comprehend *why* certain behavior and activities involve a high risk, others preferred simple, clear messages focusing on *what* to do and *how* to protect themselves. Similarly, information about health consequences caused panic for some and awareness for others.

Conclusion

There is no one-size fits all to public health risk communication, and empowering people with decision-relevant information necessitates targeted and balanced risk communication.

Background

The global COVID-19 pandemic is characterised by scientific uncertainty regarding the aetiology of the disease and uncertainty related to its management (1, 2). This poses a significant challenge for health authorities, who are required to convey information to the public even in the absence of scientific consensus. In such an intricate context, it can be helpful to understand people's mental models (3). Mental models are a concept in descriptive decision theory for explaining how people make decisions based on how they perceive their surrounding world (3) and have in particular been studied

related to the complex decision-making processes regarding risks (4-6). People's mental models are drawn from personal experience, perceptions and understanding of the world, and people use this information to respond to the risks they are faced with (3).

Studies on pandemic health risk communication that take the diversity of receivers into account is highly needed (7). The mental models approach to risk communication is one way to explore the diversity of the receivers of communication. According to the mental models approach, knowledge about people's mental models is needed in risk communication to correctly target people's information needs (6). The mental models approach aims to aid the creation of effective and tailored risk communication by identifying what the audience already knows or believes about a particular issue and addressing the decision relevant information missing from people's mental models (6). The mental model framework has been found to be useful in improving participants' context-specific knowledge and broader scientific comprehension (8), attitudes (9) and self-reported behaviour (10). It has been applied to the study of diverse infectious health risks, such as sexually transmitted diseases and sexual risk behaviour (10), HIV vaccination (11), pandemic influenza (12), COVID-19 vaccination knowledge (13) and chlamydia (14). The focus of mental model studies related to health risk has mainly been on the content of communication, i.e., improving comprehension and knowledge and correcting misconceptions. However, to design effective risk communication interventions, the communication process also matters (15). Decades of research have found that risk communication is multifaceted and variably affected by the messenger (e.g., trust), message attributes (e.g., framing, evoking emotions) and audiences (e.g., health literacy) (7, 16). Descriptive decision analysis of people's mental models can be used to gain insight into why people act the way they do to public health risk communication (4) and the role that their differing values play (3). However, none of the previous mental model studies have incorporated people's concerns with how they comprehend and mitigate health risks related to infectious diseases.

This study used COVID-19 as a case to explore how people make sense of scientific and medical information and apply it to their lives using the concept of mental models. The research question was as follows: "How does a sample of Norwegian citizens perceive and act on health risk information related to COVID-19?"

Methods

An interview study was conducted to explore representatives from the public's mental models related to COVID-19 risk. The study approach was adapted from the mental models framework (6, 17). The mental models approach by Morgan et al. (6) is a stepwise procedure starting with the creation of an expert model and summary of the scientific literature and guidelines, followed by an elicitation of decision makers' (i.e., the public's) mental models (17). Our study's findings will be used to inform a video intervention related to pandemic health risk information to be tested in an RCT (18).

Creating the expert model and the pre-determined themes and codes

We developed an expert model consisting of themes and codes; these were then used in the development of the interview guide and the analysis of data. Previous expert models have been made of infectious diseases with human-to-human transmission, including pandemic influenza (H1N1 and H5N1) (12, 19), sexually transmitted infections (10), and the HIV/AIDS pandemic (6, 20). These models broadly separate between facts and knowledge related to transmission, exposure management, the potential effect of being infected and mitigation management, and they were used to guide the development of the themes in the expert model. Thus, we included up-to-date epidemiological knowledge published by the Norwegian Institute of Public Health (NIPH) regarding COVID-19 and SARS-CoV-2 (21), as well as mitigation advice and measures (22-24) in the expert model. The four predetermined themes included transmission, exposure, mitigation, and health effects (see Table 1 for NIPH descriptions). The expert model of health risk and mitigation of COVID-19 is visualised in Figure 1.

Table 1 Descriptions derived from NIPH Jan 2021

Terminology	Descriptions
Droplet transmission	People with COVID-19 emit droplets and particles from their noses and mouths that contain SARS-CoV-2.
Contact transmission	Transmission occurs either directly through contact with a contagious person (for example, by a hug or handshake) or indirectly through contact with other surfaces contaminated with viruses (door handles, light switches, handrails)
Airborne transmission	Tiny virus-containing droplets/particles from the nose and mouth of an infectious person remain suspended in the air for a long time and move over longer distances.
Asymptomatic transmission	Someone can be infected with SARS-CoV-2 virus without developing COVID-19 and still transmit the virus further (asymptomatic carriers)
Pre-symptomatic transmission	People with COVID-19 are most contagious for 1-2 days before the onset of symptoms (pre-symptomatic period) and in the first days after the onset of symptoms

Sampling

Rather than recruiting a large representative sample, it is recommended to recruit a small but diverse sample of participants (typically 10-15 participants) when exploring mental models (17). We purposively sampled 15 participants for the individual interviews to cover a wide variety of mental models (see Table 2).

Table 2. Sample characteristics				
Nr.	Gender	Age	Education and occupation	City
1. (pilot study)	F	32	Physiotherapist, temporary laid off person	Western city and Netherland
2	F	67	Nurse, retired person	Eastern city
3	M	67	Engineer, retired person	Western small city
4	M	49	Master's degree, Computer engineer	Western city
5	F	79	Nurse, manager, retired person	Western city
6	F	65	Nurse assistant, retired person	Eastern town
7	F	19	First year university student	Northern city
8	F	19	First year university student	Northern city
9	F	19	First year university student and kindergarten assistant	Northern city
10	M	27	High school education, NGO worker	Northern city
11	M	37	High school education, firefighter	Southern small city
12	M	32	Flight pilot, temporary laid off person	Southern small city
13	M	51	Farmer, agronomist	Western town
14	M	34	Chef, offshore worker	Eastern small city
15	M	22	Electrician	Western town

The sample includes Norwegian citizens (N=7 female and N=8 male) who were between 19 and 79 years old, with various levels of education (13 -18 years of formal education), different geographical regions in Norway and diverse occupational areas (nurse, farmer, engineer, pilot, firefighter, kindergarten assistant teacher, offshore worker, IT engineer) as well as students, people temporarily laid off, and retirees. People not able to provide informed consent, e.g., people under 18 years of age and people with severe health conditions, were not included. The participants were recruited by invitation from user representatives, a non-governmental organisation representing elderly people, and the research team. All participants provided written consent to participate. The study was approved by the Norwegian Centre for Research Data (Ref. nr 583192).

The final sample was considered to provide enough information power to explore a variety of mental models related to COVID-19 risk and mitigation in the general population and to develop a rich understanding of the topic (25).

Interviews

We developed a semi-structured interview guide with open-ended questions to explore the participants' knowledge and comprehension of COVID-19 risk, perceived potential effects of COVID-19, self-protective measures, ways of learning about pandemic risk and issues of concern (6) (see Additional file 1). The interview guide was tested in a pilot interview, and the data from this interview were included in the analysis. Due to the national COVID-19 measures regarding maintaining physical distance, the participants were interviewed via a video conference (Zoom) or by telephone. The interviews lasted a mean (range) of 50 (30-76) minutes. Sound problems were occasionally experienced but were resolved by asking the participants to confirm the interviewer's interpretation during the interview.

The use of video may affect the establishment of a relationship with those at unease with using video conferences (26). To limit this risk, we asked the participants to choose their preferred mode of communication (telephone or video) to increase trust and the disclosure of information (17).

The study context

Norway has a strong public health care system, and most public hospitals are funded and owned by the state. Compared to other OECD countries, Norway is a high-trust society (27); a recent study found that 96% of the participants affirmed trusting health authorities (28). Trust in the health authorities has also been high and stable during the COVID-19 pandemic; between 80 and 90% of the population expressed a high level of trust in the health authorities during the pandemic (29), with the highest trust in the NIPH (30). A high level of trust in authorities is associated with adherence to self-protective measures during pandemics (31).

In Norway, the first case of COVID-19 was identified on February 26 (32). Since the country's first wave of COVID-19 in March-April 2020, the government's strategy has been to limit the spread of infection by employing the "TIDQ strategy" (Testing, Isolation, Infection detection and Quarantine) and by occasionally closing schools, kindergartens, and cancelling cultural events (24). The Norwegian government's goal has been to keep the spread of infection under control so that the infection is manageable and does not exceed the capacity of the health and care service and the municipal health service (33). Compared to 48 European countries, Norway has had low numbers of total positive cases (46th place) and deaths per million (45th place) due to COVID-19 (34).

The interviews were conducted between 3 February and 3 March 2021. At the time of data collection, no participants had yet received the vaccine, and the UK variant of the coronavirus (B.1.1.7) had started to spread throughout the country, which eventually led to the third wave of COVID-19 in Norway. Some of the participants lived in areas with strict societal measures, while others lived in areas with low infection rates and less strict measures. Universities were closed, work from home was recommended, and cultural events were mostly shut down.

Analysis

The interview data were analysed through a directed content analysis following Hsieh and Shannon (35), guided by de Bruins and Bostroms’ mental models framework (17). Directed content analysis is used when there is prior theory or research about a phenomenon that is incomplete and that would benefit from further conceptual development. In this case, the prior theory is expert model-based health risk information from health authorities (NIPH), and new insight was gained by adding the public’s mental models (35).

First, the interviews were transcribed into written form. SHB, SW, HT and MT read the transcripts and met to discuss their first impressions and to validate the predetermined codes created by SHB (17). SHB led the analysis and deductively coded and organised the data material into four main predetermined themes: transmission, mitigation, exposure, and consequences. In correspondence with de Bruins and Bostroms’ (17) and Hsieh and Shannon (35), SHB inductively coded and categorised the data within each pre-determined theme that was not represented by the expert model. In the final analysis, the exposure and mitigation themes were merged into one theme. The analysis was discussed and validated in collaboration with SHB, SW, HT and MT.

Results

Three themes emerged related to how the participants perceived and acted on health risk information related to COVID-19: virus transmission, exposure to risk and consequences of COVID-19 (Table 3). Quotes are displayed in Additional file 2.

Table 3 Themes and sub-themes		
Virus transmission	Exposure to risk	Consequences of COVID-19
Comprehending modes of virus transmission	Affecting exposure to risk	Imposing new models for a novel virus
Understanding words differently	Being driven by values	Building situational awareness
Acting on the uncertain evidence	Learning about mitigation in different ways	Perceiving personal health consequences differently
		Emphasising secondary consequences.

Virus transmission

The first theme, *virus transmission*, was further divided into three sub-themes: *comprehending modes of virus transmission*, *understanding words differently* and *acting on the uncertain evidence*.

Comprehending modes of virus transmission

Many of the participants reported uncertainty regarding the information from the government about modes of virus transmission. The participants had high trust in the government's advice related to virus transmission and believed in the national measures to be based on expert advice. However, some felt they lacked knowledge regarding virus transmission, and some felt confused due to the mixed health risk information received from the government.

Given the existing evidence for transmission at the time of data collection, NIPH singled out droplet transmission as the most important mode of transmission and communicated that airborne transmission and contact transmission existed but were non-significant ways of transmission. However, in the interview data, we found five different mental models of how the coronavirus transmitted, two of which did not even contain droplets. The participants described transmission in ways that could be categorised as either a) mainly droplet transmission or b) mainly through air (aerosol) transmission, c) a combination of droplet and contact transmission d) a combination of airborne and contact transmission, or e) a combination of droplet/air/contact transmission (Figure 2).

The participants expressed uncertainty related to what happened in the "airspace" with respect to the time the virus survived in the air and the distance it travelled. Few of the participants described that the distance the virus or the aerosols travelled through the air depended on dynamic conditions such as wind, ventilation, and normal breath versus sneezing. Some of the participants believed the risk of being exposed to the coronavirus depended on static and categorical measures, such as talking to someone within a one-metre distance for more than 15 minutes, while 10 minutes conversations was considered safe.

Furthermore, many of the participants expressed uncertainty related to how long the coronavirus could survive on different surfaces, such as metal, clothes, and food.

Pre-symptomatic and asymptomatic transmission were acknowledged by some of the participants. Some of the participants noted that it took some time to develop visible symptoms of COVID-19 (pre-symptomatic transmission), and some of the participants described virus transmission from people without symptoms (asymptomatic transmission). This knowledge was important for their understanding of why they had to keep distance even from their family members and why people had to quarantine. However, the participant did not necessarily receive this information from the government but rather from friends.

Understanding words differently

The words used by the NIPH to describe droplet, airborne and contact transmission were not used in everyday language by most of the participants when explaining virus transmission, who rather emphasised the behaviours transmission occurred, e.g., spitting, hugging, kissing, touching, talking. Half of the participants did not use either of the terms “droplet transmission”, “airborne transmission” or “contact transmission”. The participants also often understood the terms differently from the formal NIPH definitions. Some of the participants understood droplet transmission as saliva transmitted through physical contact with another person by kissing or touching but did not include droplets emitted from the diseased person’s mucous membranes. Furthermore, the participants’ separation between droplet and airborne transmission was not conceptually clear. Both droplet transmission and airborne transmission were described as droplets or aerosols travelling through the air, which led to conceptual confusion.

Droplet transmission was mainly described as transmission to people in close proximity through coughing, sneezing, talking or physical contact with other people. Although the NIPH additionally included hugging and kissing in their definition of (direct) contact transmission at the time of data collection, these behaviours were not associated with the term “contact transmission” by any of the participants but rather with the term “droplet transmission”. Contact transmission was mainly described as the transmission of droplets from the infected person to surfaces (e.g., shared public contact points) and then again from the hand to the mouth of another person.

Acting on the uncertain evidence

The participants acted on the uncertain evidence of virus transmission differently. For some of the elderly participants, the idea of airborne transmission and the possible severity of COVID-19 caused fear and isolation. One elderly woman described that early in the pandemic crisis, she had observed the size of the cloud of a person’s breath outdoors in the cold winter air and had thought that if there were any virus-containing droplets in that cloud, one metre of distance was too short. She had work experience from a surgical theatre and observed that people occasionally did not keep enough distance, did not wash their hands properly, and used face masks incorrectly. She had isolated herself for a year in her home due to a fear of death and the dreaded health consequences of COVID-19 and to prevent her elderly husband from being infected.

Through the government and health authorities’ risk communication, the participants had learned the importance of keeping distance and washing their hands; however, they mainly learned about virus transmission from non-governmental and informal sources.

While most of the participants acted on generic advice, such as keeping distance, washing their hands, and avoiding touching public surfaces, some described that they acted on information related to virus transmission gained through non-governmental media channels, despite acknowledging its uncertainty.

One man avoided touching metal surfaces; a woman started disinfecting her mobile phone after watching a YouTube video that visualised contact transmission. A 79-year-old woman described washing her groceries and her clothes to avoid transmission of the virus after reading a news article about three-day virus survival.

Exposure to risk

The second theme, *exposure to risk*, was further divided into three sub-themes: *affecting exposure to risk*, *being driven by values* and *learning about mitigation in different ways*.

Affecting exposure to risk

All of the participants emphasised that being physically close to others increased the risk for exposure to the coronavirus. The participants variably emphasised that the risk for exposure could be affected by one's culture (e.g., by participating in religious societies or regularly visiting pubs and cafés), hygiene knowledge or cognitive deficits (e.g., not understanding the severity of the risk, being a child or having dementia), attitudes (e.g., not caring about the risks for others and themselves), occupation (e.g., healthcare workers or bus drivers), activities (e.g., participating in parties, alcohol consumption, the use of buses) and geographical factors (i.e., population density or cities with overcrowded housing). Environmental factors were also emphasised by some of the participants as vital to prevent the spread of the virus (i.e., indoor/outdoor, large rooms, ventilation, climate). For example, a farmer explained that environmental factors prevented the spread of the virus in the agricultural context due to large buildings and ventilation.

All of the participants emphasised that they reduced their exposure to risk by keeping distance from other people and washing their hands/using anti-bacterial gel. In different ways, many participants explained how they made their own risk assessments for exposure to risk for being infected with the coronavirus. Some of the participants emphasised that receiving more information about risk activities and real-life information about infection locations, whether the activity was considered high risk, whether the outbreak was confined to a specific social environment, and whether it was under control could help them make better decisions in their daily lives.

One man aged 49 explained that receiving such information was important to be able to make his own risk assessment to make safe decisions in his daily life without necessarily locking down his personal life. He believed that the pandemic gives us waves on the sea all the way, we have to learn to navigate on the waves, emphasising the adaptation to a new normal. He felt that he had not been provided with such information by the local authorities due to privacy considerations that had been made for people who were infected.

Being driven by values

Simply understanding the importance of social distancing and hand washing was not always considered sufficient for the participants to protect themselves from the virus. Their daily decision making to reduce exposure to risk was in some conditions driven by personal values rather than a lack of knowledge. In the long term of the pandemic, some of the participants perceived that they specifically struggled to socially distance from friends and from family relatives. Some of the participants described making trade-offs between competing goals and values, i.e., reducing exposure to the virus and seeing their friends and family. A woman described that she regularly had her grandchildren over for visit, even if they had cold symptoms. She understood she exposed herself to risk, but she valued being physically close to them because those early years of childhood were of high importance for their relationships. She was afraid they would grow up not knowing her and not knowing how to hug another human being.

On other occasions, the participants' mitigation behaviour was driven by symbolic values. The use of face masks and anti-bacterial gel in food stores were perceived as symbols of trust, i.e., ways to show others that they followed the mitigation rules, as well as symbols of distrust, as some people protected themselves due to a lack of trust in others complying with the infection control measures.

Learning about COVID-19 mitigation in different ways

Health risk information related to COVID-19 was sometimes perceived as confusing, complicated, rapidly changing, and variably practised across regions. Some of the participants expressed their frustrations regarding the political debate about pandemic management. Nevertheless, the participants acknowledged the complexity and uncertainty related to pandemic management and expressed an overall high level of trust in the government and the health authorities' (NIPH) risk communication, as they were believed to provide them with the best foundation for decisions for COVID-19 mitigation.

The participants expressed the need to comprehend the *what*, *why* and *how* of COVID-19 mitigation and expressed various ways of learning about this topic. They did, however, emphasise the *what*, *why* and *how* differently.

Most of the participants emphasised obtaining clear messages on the core rules or advice on *what* to do, from explanations using familiar words and facts. The core messages were to maintain social distance, to wash hands, and to use a face mask when not able to keep a distance. They experienced that the government and the NIPH managed to communicate these core messages successfully through mass media (e.g., press conferences, NIPH webpage).

Many of the participants further emphasised the importance of comprehending the *why*, the reasons behind the national and local restrictions and advice (e.g., why isolate, why vaccinate, why quarantine, why not wear a face mask, why one-metre distance and not two, why one activity is allowed and not another), as well as the effect of some of these measures, such as the effect of using facemask and getting the vaccine. Comprehending the reasons behind the restrictions and advice was emphasised as important to accept them and act on them, especially for restrictions and advice that changed over time.

Although many of the participants perceived that the government and the NIPH managed to explain the reason for the advice and the restrictions. Some of the participants sought informal sources such as specific journalists, Snapchat, or YouTube videos where complex science information was translated into reasonable, actionable and clear messages. Others sought primary sources and scientific evidence verified by multiple sources (e.g., scientific articles, WHO and NIPH webpages) because they endeavoured to understand the foundational evidence for the decisions made by the government and thereby to comprehend the reason for the government's restrictions and mitigation advice.

Some of the participants felt overloaded with information related to restrictions, and they were not able to remain updated, focusing on the information that was relevant for their daily lives or work situations, and expressed a need for practical yet correct information on *how* to implement the mitigation measures (e.g., how to keep distance on a bus, when to quarantine, how to interpret travel rules). Those participants emphasised a need for having easily accessible, updated online information available to comprehend the messages correctly, as well as having someone to communicate with to interpret how to act on the restrictions in their context. For example, one participant emphasised the importance of communicating with the workers' organisation for farmers for their interpretation of the mitigation restrictions in the agricultural context.

Variability was found in the perception of video as a medium for learning about COVID-19. Videos were perceived as easy to learn from, memorable, and effectively speaking to emotions, but also as untrustworthy and presenting too simplistic information (mainly in the employed/recently laid off and retired groups).

Consequences of COVID-19

The third theme *consequences of COVID-19* was further divided into four sub-themes: *Needing new mental models for a novel virus*, *building situational awareness*, *perceiving personal health consequences differently* and *emphasising secondary consequences*.

Needing new mental models for a novel virus

Establishing an early understanding that "this is not a seasonal flu" was mentioned as important by some participants to understand the severity of the risk. All of the participants believed that COVID-19 had more severe health consequences than a seasonal flu. The coronavirus was perceived as causing more deaths and serious illness for those at high risk and even for healthy individuals and as causing more severe long-term health consequences than the seasonal flu. Some of the participants also mentioned that lack of immunity, the potential for anyone to become severely sick, the lack of a vaccine and the global spread of the virus were reasons that made COVID-19 more severe than the seasonal flu.

Half of the participants believed the coronavirus was more contagious than a seasonal flu, while some of the participants believed its contagiousness was comparable to that of a seasonal flu, and still some felt they were unable to compare the coronavirus to a seasonal flu due to a lack of generic knowledge about viruses and their contagiousness. Many of the participants experienced high uncertainty related to the contagiousness of the British variant virus. They needed new mental models to understand this novel virus, and creating these was an ongoing process. Their beliefs were adjusted by the information they received from the government, health authorities and multiple other sources of information.

Building situational awareness

Understanding the consequences of COVID-19 was important for building situational awareness of the severity of the crisis and creating motivation to respond. The participants differently emphasised consequences for the individual or consequences for society as vital to their situational awareness.

Several of the participants perceived that the main danger of the virus was overload on the healthcare system and loss of control, and they described catastrophic scenarios from other countries. Half of the participants expressed that the basic reproduction number (R-value), which was repeatedly communicated in the media, helped them build situational awareness related to the risk of losing control of the outbreaks; however, they experienced a lack of knowledge for comprehending the full meaning of the R-value. Some misunderstood the term as a correlation coefficient or a number of people reinfected with COVID-19. The term “exponential growth” was perceived as a complex concept to comprehend and participants emphasised that communications about the rapidly growing spread of the virus and its consequences were more important than using the actual scientific term “exponential growth”.

Protecting the elderly and those individuals with underlying diseases were the participants’ main motivations for acting on infection mitigation measures. Everyone had a person in his or her family who was at high risk of becoming severely ill or dying due to COVID-19. The variable courses of illness, from asymptomatic to suffocation and death, even for healthy individuals, made some of the participants perceive the risk as severe for all age groups. One elderly woman was afraid that the entire population of sick and elderly people would be eliminated by the virus, and she isolated herself in her house as a result of this belief.

Situational awareness was vital for the motivation to act on mitigation rules, both in the response and in the long-term phase of the pandemic. However, many struggled to keep a sustained focus after living almost a year with mitigation measures. They struggled to keep up with the constant changes in local and national restrictions, felt disengaged when watching the same type of press conferences with the same spokespersons talking about infection numbers in front of the same backgrounds and felt fatigued by listening to the same messages that described maintaining social distance and using face masks. Many emphasised that the government needed to create awareness that the pandemic could last for a long time, and they needed emphatic messages from the government acknowledging citizens’ efforts and motivating them to sustain their motivation until the population has been vaccinated.

Perceiving personal health consequences differently

The participants' need for information about individual health consequences and the disease varied. Some of the participants emphasised that they needed to understand their personal health risk better and wanted to know more about the disease and the long-term health consequences. For example, a 79-year-old woman described that she needed information about what happened if she was admitted to the hospital and what she could do to feel safe if she contracted COVID-19. She was afraid that she would not be able to cope with isolation, being alone and not being able to breathe, if she became infected with the virus.

On the other hand, some of the participants did not want information about the disease and health consequences because they believed that this information could cause panic and excessive worry for them as individuals. The variability in the need for information about the consequences of COVID-19 was illustrated by two participants who both described their reactions to the same documentary on elderly people hospitalised with COVID-19 (36). While watching the documentary had made one of the participants (woman, 65 years) so afraid that she had completely isolated herself in her home, it had helped another other person (male, 27 years) become more aware, rather than panicked of the consequences contracting the virus could have for the elderly people in his family.

Emphasising secondary consequences

The participants emphasised a broad spectrum of secondary consequences of COVID-19 mitigation strategies when discussing the major risks imposed by COVID-19. They worried about personal and global economic consequences due to the loss of income and jobs and the consequences for people's social lives and mental health, especially for children, elderly people, and students. Many struggled with loneliness, isolation, and a loss of freedom, and they felt tired of living under strict infection control measures. They reported feeling that the government had communicated different narratives appealing to collective responsibility for protecting vulnerable individuals and groups at risk and to avoid the collapse of the healthcare system. At this stage, after nearly one year of mitigating the virus, participants needed acknowledgement of their efforts, messages to help create hope, narratives to help create mental visualisations of an end to the crisis, or realistic messages that they had to sustain their social distancing and lockdowns in society for a long time. A sense of control was needed to adapt to the situation and alleviate concerns about the secondary consequences of the pandemic.

Discussion

This study exemplifies how communicating complex medical information involving risk and uncertainty is complicated by the fact that people perceive and act on the same messages differently and have varying ways of learning. Information about health consequences caused panic for some and awareness for others. Terms related to virus transmission, and exponential growth and the R-value are difficult to comprehend in the ways they have been communicated. Some want simple rules to follow, others want to

comprehend the *why*. Early situational awareness was created by understanding that “this is not a seasonal flu”, the risk of collapse of healthcare systems, the risk of losing control due to the rapid spread of the virus and the importance of protecting elderly individuals and groups at risk. Furthermore, people’s mental models changed as they learn new information.

Development of the mental models approach

The mental models approach to risk communication is strongly inspired by the knowledge of cognitive psychology (3) and the research by Tversky and Kahneman (37). According to Tversky and Kahneman (37), how people think about a phenomenon tends to persist, despite new information being available. People tend to filter new information according to its congruence with their existing understandings, beliefs and values, which is conceptualised as *anchoring bias* (37). Previous mental model studies on epidemic and pandemic risks have found that how people think about a health risk (i.e., Zika, COVID-19, pandemic influenza) is understood through their existing mental models and tends to persist (12, 13). Seasonal influenza has been most commonly used as a comparison with COVID-19 (38). Nevertheless, our study found that while people used the seasonal flu as a reference point to comprehend COVID-19, their mental models were modified by changing information.

The available evidence is rapidly changing during the COVID-19 pandemic (1). This would suggest that in addition to individual mental models, the expert model cannot be static. Additionally, as people become more informed, their mental models change. For some, the continuing refinement of peoples’ mental models supports *ongoing situational awareness* (39). The study of misconceptions and bias belongs to a *deficit model of communication* assuming there is scientific knowledge and expert knowledge that the “lay people” have to grasp (15). Considering the dynamic characteristics of pandemic threats and infectious disease outbreaks (40), future mental model studies should describe how people adapt differently to new information, what they need to know to modify their pre-existing beliefs, and how they are best supported rather than how their decision making fails to face this complexity. Future mental model studies of health risk and public communication might benefit from adopting a combined deductive-inductive approach to analysis (e.g., 35) to provide new insight not covered by the expert model (e.g., concerning issues, perception of jargon, values, preferred modes of communication), along with studying the participants’ knowledge of the formal health risk information.

This study suggests that some people make trade-offs related to *quality of life* versus *longevity of life* in the long term of the pandemic (41). Being close to grandchildren, friends and family is important to quality of life, and people may choose these values above social distancing yet be informed about the personal risk of being infected and the risk for society when spreading the virus. Emotions play a role in decision making regarding risk (42, 43), and our emotional responses are affected by the values we hold (41). Jones et al. (3) argued that peoples’ differing values need to be included in the elicitation of mental models, and our study supports that values and emotions are important to explore in descriptive decision theory approaches to risk communication, as values and emotions impact how people make decisions as well as how they perceive their surrounding world.

Making informed decisions

The intent of the mental models approach is to identify the information the public needs to make an informed decision (6). Our study highlights some considerations related to the use of technical language, empowering people, and creating awareness.

First, the findings indicate that people attach different meanings to the words used by Norwegian health experts in the NIPH. The media and health authorities may be unaware that they are using jargon, or they may overestimate people's scientific literacy and health literacy; therefore, they may overestimate the ability of people to understand the terminology that is used (44). Both jargon and simplified wording may lead to miscommunications when it has different meanings in everyday language (45). People may not necessarily comprehend what the R-value *is* and what factors affect those values, and furthermore how droplet transmission is different from airborne transmission and which factors affect exposure to risk.

Second, the study findings indicate that while people may be well informed about the required preventive measures of physical and social distancing, people may not necessarily comprehend why they need to keep their distance or how to protect themselves most efficiently under varying circumstances. To make independent and informed decisions regarding exposure to risk in their daily life, some people need more information about risk activities and risk locations and modes of virus transmission. Rather than *what* and *how*, they also need the *why*. Some people benefit from learning *which* activities and *why* certain activities involve a high risk and receiving updated information on where the risk may be higher in the long-term phase of the pandemic. Such knowledge is important to empower people to make independent choices without doing harm to others or to create undue collective burden (46). However, empowerment depends on people's capacity to act autonomously. Information that is difficult to comprehend may increase inequalities for people who do not have access or the capacity to understand the information (47). Thus, this study supports that there is no "one-size-fits-all" to public risk communication (48). Communication needs to be targeted to those who needs clear messages related to the *what* and *how* of communication, and to those who additionally needs the *why*.

Third, the study suggests that being informed in a way that facilitates comprehension of what is happening and how to avoid dangerous situations is important for initiating the response to risk and sustaining motivation. According to Endsley (39), these ideas are related to having *situational awareness*, an ongoing awareness of one's environment, and especially events that one must understand. High levels of situational awareness have been associated with social distancing behaviour (30, 49) and hand-washing behaviour (50). However, efficient and ethically sound health risk communication is a balance between providing people with information that strengthens their awareness while also avoiding the creation of panic and severe anxiety reactions (51). Although *functional fear* of COVID-19 has been found to encourage public health-promoting behaviour (52), an excessive fear of COVID-19 may increase maladaptive behaviour in the long term (53). This study finds that information about health consequences caused panic for some and awareness for others, which highlights the complexity of communicating health consequences to the public (51).

Limitations

The research findings are based on a sample of 15 citizens, which limits the generalisability of the findings. However, the use of purposive sampling reduces problems associated with this number. Analytical generalisations can be made to future studies of mental models directed at the general population regarding infectious diseases spreading between humans. This study utilised qualitative methods and can only suggest ways to improve individuals' decisions regarding COVID-19 mitigation. These suggestions need to be tested in interventions and evaluated empirically.

This study adapted the mental models approach and used online official information from the NIPH to develop a preliminary expert model. This methodology adaptation may be beneficial for the production of risk communication interventions for urgent information needs. However, to test the extent of the beliefs in the population, the mental models approach advises continuing with a survey study (6).

Conclusion

Our findings suggest that members of the public have variable levels of knowledge about how COVID-19 is transmitted and why some activities involve higher risk than others. People comprehend and act on complex information differently and put different meanings into jargon used in risk communication. While some people call for simple behavioral rules to follow, others experience that not comprehending the *why* limited their independent decision making in contexts where following rules (e.g., maintain social distance) was inadequate. To empower people to make informed and independent decisions in their daily lives, risk communication may benefit from targeted interventions that translate scientific information related to modes of virus transmission and activities with increased exposure for risk. Targeted communication needs to better consider the media channels, and the audio-visual languages best suited to their intended audience. Furthermore, when experiencing a novel virus, people need information that enables them to modify their mental models regarding why they need to act differently. In the context of the COVID-19 pandemic, the comprehension of the societal consequences that are related to the contagious nature of the virus and the protection of individuals at high risk are of great importance.

Declarations

Ethics approval and consent to participate

All participants provided informed consent to participate. The study was approved by the Norwegian Centre for Research Data (Ref. nr 583192). All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable

Availability of data and materials

Anonymised data used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

None to declare

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Authors' contributions

All authors contributed to the design of the study. SHB performed the interviews, systematised, and analysed the data. HT, SW, HT and MT all read the transcripts and provided with feedback to the analysis. All authors read and approved the final manuscript.

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Figures

Transmission	Exposure	Mitigation	Health Effects
<p>Main mode of transmission is droplet transmission</p> <p>Pre/asymptomatic and symptomatic</p> <p>Contact transmission: indirect and direct</p> <p>Airborne transmission: aerosol spread</p>	<p>Individuals with increased exposure</p> <p>Situations with increased exposure</p> <p>Contagiousness</p> <p>Mutations of the virus and contagiousness</p> <p>R- value</p>	<p>Physical (social) distance and fewer contacts</p> <p>Hand hygiene, cough etiquette, cleaning procedures, use of face masks</p> <p>Quarantine and isolation*</p> <p>Vaccination**</p> <p>Testing*</p>	<p>Symptoms</p> <p>Incubation time</p> <p>Mild, moderate, and severe courses of COVID-19</p> <p>Risk groups</p> <p>Long-term health consequences</p>

*Topics not included, as their inclusion would have required extended ethical approval. ** Covered only to a limited degree, as the interviews were conducted before people were vaccinated between February and March 2021.

Figure 1

Expert model of the health risk and mitigation of COVID-19 derived from online information, NIPH Jan 2021

Figure 2

NIPH information about main modes of COVID-19 virus transmission versus participants’ perceptions of virus transmission.

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