

Public Risk Perception Of Hydrogen Technologies In Three Countries

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In the current climate crisis, green hydrogen technologies and, in particular, their application in the transport sector, are emerging as key elements to contribute to decarbonization. Hydrogen fuel cell vehicles (HFCVs) can potentially reduce the negative effects of fossil fuels in transportation, being air pollutant-free. Introducing a network of hydrogen fueling stations (HFS) is indispensable for their market deployment, but their level of development in the world is quite uneven. Leading countries, such as Japan, have already set the basis for a network of HFS and are investing in growing the penetration rate of hydrogen vehicles in their market. In countries such as Norway, the current market share is still very low, while in others, such as Spain, it is practically non-existent.

Public concerns about hydrogen safety and accident risk perception are key issues for the successful introduction of this technology. These are intrinsically connected to risk management and spatial planning because they could escalate to public opposition to technology infrastructures and lead to low purchasing of HFCVs. This study considers social aspects of hydrogen as an important element of hydrogen sustainability.

Previous studies on HFS acceptance have identified risk perception as an important predictor of hydrogen acceptance by the public. Ono & Tsunemi (2017) in Japan reported that risk perception, together with gender, education, and vehicle usage, was a relevant explanatory factor for HFS acceptance. Also, for Japan, Hienuki et al. (2021) stated that “to introduce and disseminate new technology such as hydrogen stations, users must be made aware of the risk of using the technology until it becomes as familiar as existing gasoline station technology”. Moreover, Han et al. (2022) in South Korea reported that individual characteristics of respondents also had a significant impact on acceptance. For instance, female respondents were less receptive to building a hydrogen fueling station near their residences than male respondents, while the level of education had a positive effect on acceptance. Tarigan et al. (2012) found that age, education duration and gender influenced the likelihood to accept hydrogen refuelling stations in the Greater Stavanger region, Norway. In Japan, age, degree, and vehicle usage were also found as key predictors of HFS acceptance (Ono & Tsunemi, 2017). Recently, in a comparative study between Japan, Spain, and Norway, Huan et al. (2023) reported differentiated levels of perceived accident risk from HFS in terms of risk probability and consequences across countries. Nevertheless, generally, there is still a lack of comparative studies among countries with different levels of HFS deployment.

The objective of the present study is to compare levels of perceived risk, safety of hydrogen technologies and local acceptance of HFS in three countries, taking into account potential differences in terms of socio-demographic variables. A questionnaire survey was carried out in a web-based format. Data was collected in December 2022. 1,000 responses were collected from both Japan and Spain, and 500 from Norway ($N = 2,500$). Stratified sample considering age and gender of the populations was used, ensuring representativity of the three

subsamples. Data was analysed with SPSS 29.0 using descriptive statistics and ANOVAs for the comparative analysis.

Japan showed significantly higher levels of perceived risk of hydrogen technologies than Spain and Norway. Likewise, Spain exhibited higher levels of perceived safety of hydrogen technologies compared to Norway and Japan. Regarding general acceptance of hydrogen technologies, the highest levels were obtained in Spain, followed by Norway and Japan. For what it concerns the local acceptance of HFS, again, the highest levels were obtained in Spain. Finally, in Norway there was an increased awareness of hydrogen-related accidents than in Spain or Japan.

Table 1. Risk perception in the three countries: mean and standard deviation (* $p < 0.05$)

Variables	Levels	Japan	Spain	Norway
Gender	Male	3.07 (0.61)	2.71* (0.82)	2.67* (0.85)
	Female	3.05 (0.60)	2.80* (0.79)	2.82* (0.78)
Age	18-28 years	3.03 (0.58)	2.75 (0.89)	2.70 (0.74)
	29-39 years	2.98* (0.64)	2.90* (0.83)	2.77 (0.76)
	40-50 years	3.06 (0.58)	2.77 (0.78)	2.69 (0.91)
	51-60 years	3.15* (0.57)	2.63* (0.81)	2.73 (0.89)
	+60 years	3.11 (0.63)	2.70 (0.73)	2.86 (0.81)
Education	High school or below	3.02 (0.61)	2.69 (0.77)	2.62* (0.83)
	Secondary technical school	3.09 (0.60)	2.74 (0.80)	2.64 (0.79)
	Undergraduate	3.07 (0.58)	2.78 (0.79)	2.86* (0.81)
	Postgraduate	3.27 (0.73)	2.78 (0.90)	2.90 (0.81)
Car usage	None (0 days a week)	3.01 (0.61)	2.71 (0.65)	2.75 (0.67)
	Low (1 to 3 days)	3.13 (0.58)	2.79 (0.81)	2.83 (0.94)
	Moderate (4 or 5 days)	2.99 (0.67)	2.73 (0.84)	2.75 (0.77)
	High (6 or 7 days)	3.10 (0.58)	2.76 (0.81)	2.70 (0.85)
Accident awareness	Yes	3.14* (0.69)	2.97* (0.85)	2.78 (0.88)
	No	3.04 (0.58)	2.67* (0.77)	2.71 (0.77)

When considering socio-demographic characteristics, we found statistically significant differences mainly in terms of age for Japan: the elderly seemed to perceive risk as higher. In Spain, differences in perceived risk were found by gender, as females showed higher levels of perceived risk, and by age: younger seemed to perceive risk as higher. In Norway, we found differences by gender (again, females perceived risk to be higher) and education; those with a university degree (undergraduate or postgraduate) showed a higher perceived risk level. When considering accident awareness, we found statistically significant differences in Japan and Spain (Table 1).

Overall, we found interesting differences regarding perceived risk, safety of hydrogen technologies and acceptance of HFS among the three studied countries, which stimulates a reflection on the cultural elements of societal risk perception. Findings suggest that the country context should be taken into account when considering risk perception of hydrogen technologies. As stated by Bogel et al. (2018) regular monitoring on a country-specific level is recommended, reflecting country differences in the degree of diffusion of hydrogen technologies. In addition, relevant differences were found in terms of demographic characteristics of the participants. The results provide useful insights to enhance hydrogen communication campaigns and to prepare exchanges of opinions with residents when new infrastructures are going to be installed in the studied countries.

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