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Contents

Original Papers

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Original Paper

Evaluation of Web-Based Consumer Medication Information: Content and Usability of 4 Australian Websites

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Abstract

Background: Medication is the most common intervention in health care, and written medication information can affect consumers' medication-related behavior. Research has shown that a large proportion of Australians search for medication information on the Internet.

Objective: To evaluate the medication information content, based on consumer medication information needs, and usability of 4 Australian health websites: Better Health Channel, myDr, healthdirect, and NPS MedicineWise .

Methods: To assess website content, the most common consumer medication information needs were identified using (1) medication queries to the healthdirect helpline (a telephone helpline available across most of Australia) and (2) the most frequently used medications in Australia. The most frequently used medications were extracted from Australian government statistics on use of subsidized medicines in the community and the National Census of Medicines Use. Each website was assessed to determine whether it covered or partially covered information and advice about these medications. To assess website usability, 16 consumers participated in user testing wherein they were required to locate 2 pieces of medication information on each website. Brief semistructured interviews were also conducted with participants to gauge their opinions of the websites.

Results: Information on prescription medication was more comprehensively covered on all websites (3 of 4 websites covered 100% of information) than nonprescription medication (websites covered 0%-67% of information). Most websites relied on consumer medicines information leaflets to convey prescription medication information to consumers. Information about prescription medication classes was less comprehensive, with no website providing all information examined about antibiotics and antidepressants. Participants (n=16) were able to locate medication information on websites in most cases (accuracy ranged from 84% to 91%). However, a number of usability issues relating to website navigation and information display were identified. For example, websites not allowing combinations of search terms to be entered in search boxes and continuous blocks of text without subheadings.

Conclusions: Of the 4 Australian health information websites tested, none provided consumers with comprehensive medication information on both prescription and nonprescription medications in a user-friendly way. Using data on consumer information

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needs and user testing to guide medication information content and website design is a useful approach to inform consumer website development.

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KEYWORDS

consumer health information; health communication; prescription drugs; nonprescription drugs; drug information service; Internet; usability testing

Introduction

Medication is the most common intervention in health care [1]. A 2010 survey of 12,262 consumers revealed that approximately 80% of Australians sought health information on the Internet, and of these individuals, approximately 70% sought information on medication [2]. Focus groups with Australian consumers showed that consumers viewed the Internet as an important source of medication information, but also that consumers varied in their search and appraisal skills [3]. Examining written medication information available on the Internet is of value as this information has the potential to affect consumers' medication taking behavior and satisfaction [4,5].

Evaluations of Web-based health information have typically utilized instruments with various criteria [6] covering technical details (eg, disclosure of authorship and sponsorship, provision of references) [7], design features (eg, layout, speed), readability (eg, Flesch Reading Ease, Simple Measure of Gobbledygook (SMOG)) [8,9], accuracy, and completeness of information. However, many of the criteria lack validity and reliability and have certain gaps [6,10-12]. For example, a 2002 systematic review of the criteria used to evaluate health websites identified user testing as a neglected area [6]. More recently, user testing has been used to assess websites in a number of studies and has highlighted the importance of this approach in usability evaluation [13,14]. For example, 1 study used 4 rounds of user testing to improve an Internet-based hemophilia self-management tool for adolescents [13]. Another study used user testing and identified the need for websites to take user age into account in their design [14].

Although there have been numerous evaluations of Web-based health information [6,10], fewer studies have evaluated Web-based medication information [3,9,15-22]. Given the importance of Web-based medication information to consumers [23], this study aimed to evaluate the medication information on 4 frequently used Australian websites. The evaluation took a unique approach by evaluating both website content and usability and by being guided by data on consumer medication information needs.

Methods

A mixed-method approach was used in this study comprising (1) an assessment of consumer medication information needs, (2) a website content evaluation using the consumer information needs, and (3) user testing of websites (including qualitative interviews).

Identification of Consumer Medication Information Needs

Consumer medication information needs were determined by examining the most frequently used medications in Australia and the most frequent consumer medication queries made to the healthdirect helpline. The top 5 most commonly used prescription and nonprescription medications in Australia were extracted from the Pharmaceutical Benefits Scheme (PBS) [24] and the National Census of Medicines Use, respectively [25]. The top 5 prescription medications, by defined daily dose/1000 population/day, were atorvastatin, rosuvastatin, perindopril, irbesartan, and candesartan [24]. The top 5 nonprescription medications (excluding paracetamol) used by survey respondents in the past month were fish oil supplements (26.1% of respondents), aspirin (21.5% of respondents), glucosamine (17.5% of respondents), calcium (12.3% of respondents), and cholecalciferol or vitamin D (11.4% of respondents) [25]. Paracetamol (used by 42.9% of respondents in the last month) was excluded from this list as it was the subject of the most frequent consumer medication query made to the healthdirect helpline (see below).

The consumer medication queries made to the healthdirect helpline in November 2014 were extracted and reviewed to determine the medication therapeutic class that was the subject of the call and the query regarding the medication (eg, what to do if a dose was missed). The healthdirect helpline is a free 24-hour health advice telephone line that covers approximately 56% of Australia's population. The telephone service receives between 60,000 and 70,000 calls per month, with medication queries the most frequent clinical issue discussed [26]. In November 2014, the most frequent medication classes (and specific medication within each class) were analgesics (paracetamol, ibuprofen, and paracetamol and codeine), antibiotics (amoxicillin), antidepressants (sertraline), antihistamines (promethazine), and anticoagulants and antithrombotic agents (warfarin). The most common queries regarding each of these medication classes varied. However, the top 3 queries for all types of medications were (1) how to take a medication (how much to take, what to do if a dose is missed, and what to do in an overdose), (2) medication interactions, and (3) medication side effects.

Identification of Websites

We aimed to identify websites for the evaluation that consumers would most frequently encounter when using the Google search engine for medication queries. Search terms related to the top medications and queries outlined above were entered into Google. The 4 most frequently generated Australian health websites providing consumer medication advice were selected.

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Websites specific to a condition, a medication, or a population group were excluded (eg, beyondblue, a website targeting mental health [27]; Royal Children's Hospital Melbourne targeting pediatric patients [28]). The 4 websites included in our evaluation were Better Health Channel [29], myDr [30], healthdirect [31], and NPS MedicineWise [32].

Assessment of Website Content

First, each website's content on the prescription and nonprescription medications identified from the PBS and National Census of Medicines Use was assessed with respect to the extent to which it covered the 3 most frequent medication queries to the healthdirect helpline (ie, how to take a medication, interactions, and side effects). Additionally, whether each website had an information page about the therapeutic classes of these medications was examined. For example, for atorvastatin, websites were evaluated on the extent to which they covered information on how to take the medication (how much to take, what do to if a dose is missed, and what to do in an overdose), interactions, and side effects as well as whether there was a general page on hypolipidemic medications.

Second, each website's content was assessed with respect to whether it covered the most frequent medication classes that were the subject of calls to the healthdirect helpline and each class's most frequent queries. Whether each website included information on the most frequent medication within each class was also examined. For example, when providing information on antibiotics, whether the website covered missed doses, interactions, and stopping an antibiotic were assessed, along with whether there was any specific information on amoxicillin. For analgesics and antipyretics, information on paracetamol, ibuprofen, and paracetamol and codeine was examined, as these were by far the most frequent medication types queried and these medicines are available over the counter (nonprescription).

A coding system was applied to indicate the extent to which information on each medication query was available on the websites. Two investigators (MZR and LR) initially tested the coding system to ensure it was suitable and reliable (ie, produced the same code when applied independently by 2 reviewers). Subsequently, a single investigator (LR) coded the queries on all websites. Each query was coded as either covered (C), that is, the information provided on the website was comprehensive enough to fully answer the query; partially covered (PC), that is, there was information related to the query, but it did not answer the query specifically; referred (R), that is, the website referred users to another site that answered the query; and not covered (and not referred; NC). By way of example, for the query "what medications does aspirin interact with?" a website was coded as covering the information if it provided a list of medications with which aspirin interacts but partially covered if it only stated that aspirin interacted with some medications and asked the user to seek advice from a health professional.

Website content assessment was conducted in January 2015.

User Testing

We developed scenarios for testing based on the medication calls made to the healthdirect helpline outlined above. The most frequently queried medications were combined with the most frequently asked questions to create the scenarios. The scenarios consisted of 8 questions, all of which had answers available on the test websites (Textbox 1). Thus the scenarios sought to test the ease and speed with which users were able to find information that was contained on the websites.

Textbox 1. Scenarios used for website user testing.

1. Can I take Panadeine Forte (paracetamol 500 mg and codeine phosphate 30 mg per dosing unit) while breastfeeding?
2. It is safe to take my antibiotic (Keflex: cephalexin) with Panadol (paracetamol)?
3. I missed a dose of my antibiotic (Amoxil: amoxicillin), what do I do?
4. What is warfarin (Coumadin) used for?
5. I'm feeling better, can I stop my antibiotic (erythromycin: Eryc)?
6. Is nausea a side effect of my antidepressant (Zoloft: sertraline, a selective serotonin reuptake inhibitor)?
7. Does warfarin interact with Nurofen (ibuprofen, a nonsteroidal anti-inflammatory drug)?
8. Is it safe to take Telfast Decongestant tablets (fexofenadine hydrochloride 60 mg and pseudoephedrine hydrochloride 120 mg per dosing unit) while pregnant?

Table 1. Website sequences used for user testing scenarios.

Sequence	Website 1	Website 2	Website 3	Website 4
1	healthdirect	NPS MedicineWise	myDr	Better Health Channel
2	Better Health Channel	healthdirect	NPS MedicineWise	myDr
3	myDr	Better Health Channel	healthdirect	NPS MedicineWise
4	NPS MedicineWise	myDr	Better Health Channel	healthdirect

Consumers who were unfamiliar with the target websites took part in user testing. To recruit participants, posters were displayed at Macquarie University, Sydney campus, Australia. Participants received a complimentary lunch for taking part.

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Participants were observed by a single investigator (MTB) while performing the 8 scenario tasks using the websites. To complete each task, the user was required to answer each medication-related query by locating relevant information on a website. Tasks were completed in a fixed order but the order of website use varied between subjects to minimize any learning effects, with each participant randomly allocated to 1 of 4 sequences listed in Table 1. Thus, as there were 8 scenarios, each participant used each website twice to locate a piece of information. User testing was conducted in January and February 2015.

The variables collected by the observer during each scenario were time taken to locate the desired medication information; number of screens required to locate the piece of medication information; number of new searches a user performed (ie, new entries into a search box); the user's search method (eg, whether he or she used the search box or browsed subheadings); whether the user was successful in completing the task (ie, answered the question correctly); and any obvious negative affect (eg, frustration).

After completion of 4 scenarios (on 2 websites) participants took a short break and were asked to comment on the 2 websites they had just used. They were asked to indicate which website they preferred and why, to describe good and bad features of the websites, and to comment on the layout of information on the screen and on how understandable the website content was. Participants then completed the remaining 4 scenarios and were interviewed about the 2 additional websites. Finally, participants were asked to indicate which of the 4 websites was their preferred website and why and to describe an ideal website for locating medication information.

Nonparametric Friedman tests were used to detect the differences across the websites on time taken to locate information, number of screens required, and number of new searches. A generalized estimating equation approach, with consideration of the correlation of measurements from the same participant, was used to compare the websites on proportion of tasks successfully completed. Results were considered significant when $P \leq .05$.

Results

Assessment of Website Content

Table 2 shows website coverage of the most commonly used prescription medications in Australia. Table 3 shows the total percentage of website coverage of the most commonly used prescription medications in Australia. Of the four websites, 3 (NPS MedicineWise, myDr, and Better Health Channel) covered each of the queries related to the medication, and the healthdirect website referred consumers to other sources for the information. All websites had a general information page on hypolipidemic and antihypertensive medications.

Table 4 shows website coverage of the most commonly used nonprescription medications in Australia. Table 5 shows the total percentage of website coverage of information on the most frequently used nonprescription medication in Australia. Compared with prescription medication, information on nonprescription medication was less comprehensive. Whereas all common queries related to these medications were covered by multiple websites for aspirin, calcium, and vitamin D, no website covered all queries on fish oil supplements and glucosamine. Three of the four websites covered general information on both anticoagulants/antithrombotic agents, and complimentary medicines.

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Table 2. Website coverage of information on the most frequently used prescription medications in Australia.

Prescription medication information		healthdirect	NPS MedicineWise	myDr	Better Health Channel
Atorvastatin					
	How to take it[a]	R[b]	C[c]	C	C
	Interactions	R	C	C	C
	Side effects	C[d]	C	C	C
Rosuvastatin					
	How to take it[a]	R	C	C	C
	Interactions	R	C	C	C
	Side effects	C[d]	C	C	C
Perindopril					
	How to take it[a]	R	C	C	C
	Interactions	R	C	C	C
	Side effects	R	C	C	C
Irbesartan					
	How to take it[a]	R	C	C	C
	Interactions	R	C	C	C
	Side effects	R	C	C	C
Candesartan					
	How to take it[a]	R	C	C	C
	Interactions	R	C	C	C
	Side effects	R	C	C	C

[a]How to take it includes how much to take, what to do if a dose is missed, and what to do in an overdose. Inclusion of all 3 resulted in a rating of C; if only 1 or 2 items were covered, then a rating of PC (partially covered) was given.

[b]R: referred to an external site.

[c]C: covered.

[d]Covered on a general page about statins, which mentions atorvastatin and rosuvastatin.

Table 3. Total percentage of website coverage of information on the most frequently used prescription medications in Australia.

Total coverage (%)	healthdirect	NPS MedicineWise	myDr	Better Health Channel
Covered	13	100	100	100
Partially covered	0	0	0	0
Referred	87	0	0	0
Not covered	0	0	0	0

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Table 4. Website coverage of information on most frequently used nonprescription medications in Australia.

Nonprescription medication information		healthdirect	NPS MedicineWise	myDr	Better Health Channel
Aspirin					
	How to take it[a]	R[b]	PC[c]	C[d]	C
	Interactions	R	C	C	C
	Side effects	PC	C	C	C
Fish oil supplements					
	How to take it[a]	R	PC	NC[e]	PC
	Interactions	R	C	NC	NC
	Side effects	R	C	PC	NC
Glucosamine					
	How to take it[a]	R	PC	NC	NC
	Interactions	R	PC	NC	C
	Side effects	R	C	NC	NC
Calcium					
	How to take it[a]	R	PC	C	C
	Interactions	R	NC	C	C
	Side effects	R	PC	C	C
Cholecalciferol (vitamin D)					
	How to take it[a]	R	PC	PC	C
	Interactions	R	C	NC	C
	Side effects	R	C	C	C

[a]How to take it includes how much to take, what do to if a dose is missed, and what to do in an overdose. Inclusion of all 3 resulted in a rating of C; if only 1 or 2 items were covered then a rating of PC was given.

[b]R: referred to an external site.

[c]PC: partially covered.

[d]C: covered.

[e]NC: not covered (and not referred).

Table 5. Total percentage of website coverage of information on the most frequently used nonprescription medications in Australia.

Total coverage (%)	healthdirect	NPS MedicineWise	myDr	Better Health Channel
Covered	0	47	47	67
Partially covered	7	47	13	7
Referred	93	0	0	0
Not covered	0	6	40	27

Table 6 shows website coverage of the most common queries to the healthdirect helpline related to analgesics and antipyretics. Table 7 shows the total percentage of website coverage of queries to the healthdirect helpline related to simple analgesics and antipyretics. Each query was covered by at least one website for each medication, except for paracetamol and codeine, where no website contained information on whether it is safe to take another dose of paracetamol and codeine after vomiting. No website covered all the queries for paracetamol, and only 1 site (myDr) covered all the queries for ibuprofen.

Table 8 shows the websites' coverage of the queries that the healthdirect helpline has received related to antibiotics, antidepressants, antihistamines, and anticoagulants and antithrombotic agents. Table 9 shows website coverage of general information queries to the healthdirect helpline related to antibiotics, antidepressants, antihistamines, and anticoagulants and antithrombotic agents. Table 10 shows the total percentage of website coverage of queries to the healthdirect helpline related to antibiotics, antidepressants, antihistamines, and anticoagulants and antithrombotic agents. General information on each

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medication class was available from at least one website, except for antihistamines, with no website providing general information on this drug class. Information on missed doses of antidepressants was not covered by the websites and that on missed doses of antibiotics was only partially covered by 1 website (NPS MedicineWise). The most common queries related to antibiotics, antidepressants, and antihistamines were not all covered by any one site.

Table 6. Website coverage of queries to the healthdirect helpline related to simple analgesics and antipyretics.

Queries for analgesics and antipyretics		healthdirect	NPS MedicineWise	myDr	Better Health Channel
Paracetamol					
	How much to take (children)	PC[a]	PC	C[b]	PC
	Interactions	PC	C	C	NC[c]
	Overdose	C	C	NC	C
Ibuprofen					
	How much to take (children)	PC	PC	C	C
	Interactions	R[d]	C	C	NC
	Overdose	R	NC	C	C
Paracetamol and codeine					
	Interactions	PC	PC	PC	C
	Overdose	PC	C	C	C
	Vomited after taking, is it safe to take another dose	NC	NC	NC	NC

[a]PC: partially covered.

[b]C: covered.

[c]NC: not covered (and not referred).

[d]R: referred to an external site.

Table 7. Total percentage of website coverage of queries to the healthdirect helpline related to simple analgesics and antipyretics.

Total coverage (%)	healthdirect	NPS MedicineWise	myDr	Better Health Channel
Covered	11	44	67	56
Partially covered	56	33	11	11
Referred	22	0	0	0
Not covered	11	22	22	33

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Table 8. Website coverage of queries to the healthdirect helpline related to antibiotics, antidepressants, antihistamines, and anticoagulants and antithrombotic agents.

Queries	healthdirect	NPS MedicineWise	myDr	Better Health Channel
Antibiotics				
Interactions	R[a]	PC[b]	PC	NC[c]
How long to take it for	R	C[d]	C	NC
Missed dose	NC	PC	NC	NC
Antidepressants				
Interactions	PC	C	PC	NC
Starting and stopping	PC	C	C	C
Missed dose	NC	NC	NC	NC
Antihistamines				
How much to take (children)	R	NC	NC	NC
Interactions	R	NC	NC	NC
Use in breastfeeding	R	C[e]	NC	NC
Anticoagulants, antithrombotic agents				
Interactions	R	C	C	NC
Side effects	R	C	C	NC

[a]R: referred to an external site.

[b]PC: partially covered.

[c]NC: not covered (and not referred).

[d]C: covered.

[e]Information on use of antihistamines while breastfeeding was on a page about medication use in breastfeeding.

Table 9. Website coverage of general information queries to the healthdirect helpline related to antibiotics, antidepressants, antihistamines, and anticoagulants and antithrombotic agents.

Queries	healthdirect	NPS MedicineWise	myDr	Better Health Channel
Antibiotics				
General information?	Yes	Yes	Yes	No
Specific information on amoxicillin?	No	Yes	Yes	Yes
Antidepressants				
General information?	Yes	Yes	Yes	Yes
Specific information on sertraline?	No	Yes	Yes	Yes
Antihistamines				
General information?	No	No	No	No
Specific information on promethazine?	No	Yes	Yes	Yes
Anticoagulants, antithrombotic agents				
General information?	Yes[a]	Yes	Yes	No
Specific information on warfarin?	Yes[a]	Yes	Yes	No

[a]Information provided on a page about stroke treatment.

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Table 10. Total percentage of website coverage of queries to the healthdirect helpline related to antibiotics, antidepressants, antihistamines, and anticoagulants and antithrombotic agents.

Total coverage (%)	healthdirect	NPS MedicineWise	myDr	Better Health Channel
Covered	0	55	36	9
Partially covered	18	18	18	0
Referred	64	0	0	0
Not covered	18	27	45	91

User Testing

A total of 16 consumers were recruited for user testing. The median age was 27 years (range 18-66) and 8 out of 16 participants (50%) were male. When asked how frequently they used the Internet, all participants reported that they used the Internet "multiple times a day." When asked how often they used the Internet to find medication information, typical responses were "never" (n=7), "rarely" (n=4), and "once per month" (n=2).

Table 11 shows results of user testing. The number of screens viewed while completing scenarios using NPS MedicineWise and myDr were fewer than those viewed when using healthdirect and Better Health Channel (Friedman's χ^2_3=9.02, *P*=.03). However, there was no evidence to indicate differences in the time taken to complete scenarios (Friedman's χ^2_3=5.47, *P*=.14), the number of new searches performed (Friedman's χ^2_3=3.04, *P*=.39), or in the accuracy with which participants completed the scenarios (χ^2_3=1.34, *P*=.72).

Of the 16 participants, 11 participants (69%) indicated NPS MedicineWise was their preferred website, 4 participants (25%) said myDr, and 1 participant preferred healthdirect to the other websites.

Table 11. Results of scenario-based user testing of websites.

Key results	healthdirect	NPS MedicineWise	myDr	Better Health Channel
Median time taken to complete a scenario (range)[a]	3 min[b] 37 s[c] (1 min 13s to 16 min 3s)	2 min 56s (1 min 12s to 8 min 56s)	2 min 41s (49s to 9 min 16s)	4 min 34s (1 min 47s to 12 min 31s)
Median number of screens viewed (range)	10 (3-34)	7 (2-17)	7 (3-15)	10 (5-17)
Median number of new searches (range)[a]	2 (0-7)	0 (0-4)	2 (0-6)	2 (0-9)
Percentage correct[a]	75%	75%	81%	69%

[a] No evidence to indicate differences between websites.

[b] min: minute.

[c] s: second.

Overall, it appeared to be more difficult for participants to locate the appropriate page of information for each scenario than to find the relevant piece of information on a page. In 84 of the 128 (65.6%) scenarios observed, participants began the scenario by entering a keyword or keywords into the home page search box. In 32 of the 128 scenarios (25.0%), participants looked for the website's medicine page before searching for a particular medication name. When trying to locate a piece of information on a webpage, more than half the participants (n=10) used a keyboard shortcut (ie, control-F) to find a keyword (eg, pregnancy) on the page, whereas the remaining participants scrolled through the information.

Participant interviews provided further information on their perceptions of the usability of websites. All participants reported that information displayed on websites was presented at the right level of difficultly, although some suggested that content was understandable because they were students or researchers:

> *I think there would be a not insignificant proportion of the population that would struggle with it, because they would baulk at the terminology that's used.* [P11]

The inability to search using combinations of search terms (eg, Panadeine Forte AND pregnancy) was identified to be a negative aspect of websites by participants:

> *Yeah, so if it would work more like Google where I would type in the keywords of what I was looking for then that would be much easier. That was something that I noticed all the websites didn't do.* [P1]

Users also reported that being directed to PDF versions of consumer medicines information (CMI) leaflets was problematic:

> *It's really wordy and the format of it, because it's set up, to me, it's set up like a physical pamphlet, so if I had that in my hands, that's fine but on the screen, the three column thing with the same format and the font of a physical pamphlet doesn't work...it makes*

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> *skimming much harder because, I mean, I could do it but it just took me longer.* [P4]

A large number of menus and drop-down menus on the home page resulted in participants using the search box rather than browsing the website:

> *Yeah, so it's very all over the place really. You really don't know where to start with that one so you're almost forced to go to search this side.* [P10]

The listing of medications only by generic names or brand names, not both, was identified as a barrier to finding relevant information, as users were not necessarily familiar with both terms:

> *It can be confusing with generic versus brand names, because I know one, when that I was initially looking for Zoloft I looked at that list of anti-depressants and I think they only had the generic names so I didn't see Zoloft on that list, so I think it's important to have both written.* [P3]

Websites presenting medication information in a separate location from health information was perceived as a problem because users generally viewed medication information as a subset of health information, not as a separate category of information:

> *I think it should be more integrated because I think that that's logically how people think. They see health as being the generic term and medicine a subset within.* [P11]

The large number of results being generated from search-box queries was also considered a barrier to locating information:

> *It's like when you're searching, it kind of gives you every possible result rather than the one you probably want, the common one. Well, I don't know, I mean, it's hard to get that balance between only throwing up a few common ones, and the person could miss out on what they want to see, or throwing up everything and the person just gets, like, what is all this?* [P16]

Participants viewed features of websites that broke up large amounts of text (eg, subheadings, highlighting, or hyperlinked subheadings) as helpful:

> *Subheadings are very good. Especially when you know what you are looking for.* [P1]
>
> *I think that in terms of NPS [MedicineWise] there was more bold so I found it easier to read because then I would just skim and if the bold didn't apply then I would just ignore the regular font.* [P4]
>
> *Bullet points are good. I mean, you don't want massive slabs of information that you need to search through.* [P5]
>
> *You don't want to sit there reading through it all. Having those little jumping links is helpful if you are looking for a particular bit of information.* [P15]

Additionally, auto-completion of search terms in search boxes was reported to be a positive feature of websites:

> *I like that if you search something there are suggestions for what you are searching.* [P6]

Discussion

Principal Findings

Several limitations were identified in the medication information available on 4 Australian health websites in relation to both content and usability. Although detailed information on specific prescription medication was provided, information on nonprescription medication and medication classes was less comprehensive. Several website features affected how quickly and easily users were able to locate medication information.

Information on the most common prescription medications and most frequent medication queries made to the healthdirect helpline were covered or referred by all 4 websites. The healthdirect website was the only website to refer consumers to other websites. This is because the healthdirect website acts as a portal site that directs consumers to other sources of reliable health information. The majority of the prescription medication information was available through CMI leaflets, either embedded into webpages (NPS MedicineWise, myDr) or as a link to a PDF file (Better Health Channel). CMI content is regulated by the Australian Government and is prepared by and the responsibility of pharmaceutical companies [33]. Although CMI leaflets provide consumers with the full scope of information on a specific medication, the amount of information they present may be overwhelming for consumers [5,33]. Furthermore, CMI leaflets have been criticized for not promoting medication adherence because they include only limited information on the benefits of taking medications [33]. Thus, although it is not feasible for a website to develop its own content on every prescription medication, the inclusion of general pages on medication classes may be an opportunity to provide consumers with more concise information than CMI leaflets, including content on the benefits of taking a medication [5]. In this study, we found the general information pages on 2 prescription medication classes, antibiotics and antidepressants, to be limited in their scope on all websites for answering frequent consumer medication queries.

The way CMI content is displayed on the websites also appeared to be problematic. The inclusion of a link to a PDF version of the "paper" leaflet (as on Better Health Channel), which includes three columns of text, was not viewed favorably by consumers. This was primarily because the layout required users to continuously scroll up and down to read the text. Consumers preferred CMI content to be embedded into the webpage in a single column, as done on NPS MedicineWise and myDr. Interestingly, an assessment of consumer needs in relation to printed CMI leaflets also noted that consumers preferred a single-column layout [33].

Information on nonprescription medication was less comprehensively covered on the websites than prescription medication. The nonprescription medication or medication classes examined in this study included paracetamol, ibuprofen, paracetamol and codeine (formulations with codeine≤12 mg/unit), antihistamines, aspirin, fish oil supplements, glucosamine, calcium, and cholecalciferol. Nonprescription

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medications do not require a CMI leaflet according to Australian regulations. Instructions for use typically appear in or on the packaging. However, as is evident from the large volume of calls made to the healthdirect helpline about these medications, consumers may not always read, keep, or understand packaging instructions, or all the required information may not be provided on packaging instructions.

Of the nonprescription medicines examined in this study, 5 were complementary medicines. Complementary medicines are a subset of nonprescription medicines that can be defined as herbal, natural, or alternative medicines and include vitamins, minerals, herbs, and nutritional supplements. Australian studies estimate that 50% of complementary medicine users also take conventional medicines [34] and more than half of these consumers do not report complementary medicine use to their doctor [34,35]. Of complementary medicine users, 75% are unaware that the products are not tested for quality and safety by the Australian Therapeutic Goods Administration [34]. Yet, our results showed complementary medicines were the least comprehensively covered by the websites evaluated. There appears to be a significant gap in information available to consumers to make informed decisions about their use of these products. This is particularly salient because the quality of Web-based information on complementary medicines is limited [36].

Although the content of websites is important, it is also crucial for information to be easily located. Usability issues related to both website navigation (ie, locating the correct page) and information display (ie, locating information on a page) were identified in this study. A key navigation issue was that websites did not allow users to search using multiple keywords, as is typically the case in search boxes. This caused users to become extremely frustrated and resulted in delays. Information layout was important for locating content on a page, with participants preferring text to be broken up using subheadings, highlighting, or bullet points. These features are in line with those identified in a previous assessment of consumer needs related to printed CMI leaflets [33]. The NPS MedicineWise website was preferred by the majority of user testing participants. The layout of the NPS MedicineWise website was looked upon favorably by participants and was most likely the reason participants were required to navigate through fewer screens to locate information on this website compared with the other websites.

Limitations

This study had a number of limitations. The assessment of consumer medication information needs was based on calls to a national health helpline and the most commonly used prescription and nonprescription medications. Consumer queries from other sources, such as health professionals (physicians and pharmacists), were not captured. Additionally, there may be important medication safety issues not recognized by consumers but for which there is limited information, and our methods would not have captured these. The accuracy or the readability level of the medication information on the websites was not evaluated as part of this study. However, a recent study assessing the readability of 251 Australian health webpages found that their readability was above the average Australian levels of reading [8]. Thus, clearly, this is also an important consideration for website design. Lastly, the number of participants used for user testing, although likely large enough to detect most issues [37], limited our ability to detect statistically significant differences between websites for indicators tested. Despite these limitations, the study presents an innovative approach to the evaluation of medication information on websites and identified medication information gaps not previously recognized. Addressing these gaps may improve the safe use of medicines in the community.

Conclusions

This study applied a unique approach, guided by consumer medication information needs, to assess the content and usability of medication information on 4 Australian websites. Several gaps were identified with respect to website content, and several usability issues were identified with respect to navigation and information presentation. Results showed that the 4 Australian websites tested did not provide consumers with comprehensive medication information on both prescription and nonprescription medications in a user-friendly way. Additional content (eg, on nonprescription medication) and some simple redesign of content (eg, single-column text with bullet points) would improve both the content and usability of widely used Australian websites.

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Authors' Contributions

MTB, MB, MR, JIW, MZR, AT, and LL contributed to the study design. LL analyzed medication query call data. MZR and MTB designed the user testing scenarios and website content assessment. LR assessed websites for medication information content. MTB conducted user testing and analyzed qualitative user testing data. LL analyzed quantitative user testing data. MTB, JIW, MZR, AT, LL, and LR contributed to the analysis and interpretation of the data. All authors reviewed the manuscript for content and approved the final version for publication.

Conflicts of Interest

None declared.

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Abbreviations

CMI: consumer medicines information
PBS: Pharmaceutical Benefits Scheme

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Original Paper

Adopting Quality Criteria for Websites Providing Medical Information About Rare Diseases

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Abstract

Background: The European Union considers diseases to be rare when they affect less than 5 in 10,000 people. It is estimated that there are between 5000 and 8000 different rare diseases. Consistent with this diversity, the quality of information available on the Web varies considerably. Thus, quality criteria for websites about rare diseases are needed.

Objective: The objective of this study was to generate a catalog of quality criteria suitable for rare diseases.

Methods: First, relevant certificates and quality recommendations for health information websites were identified through a comprehensive Web search. Second, all considered quality criteria of each certification program and catalog were examined, extracted into an overview table, and analyzed by thematic content. Finally, an interdisciplinary expert group verified the relevant quality criteria.

Results: We identified 9 quality certificates and criteria catalogs for health information websites with 304 single criteria items. Through this, we aggregated 163 various quality criteria, each assigned to one of the following categories: thematic, technical, service, content, and legal. Finally, a consensus about 13 quality criteria for websites offering medical information on rare diseases was determined. Of these categories, 4 (data protection concept, imprint, creation and updating date, and possibility to contact the website provider) were identified as being the most important for publishing medical information about rare diseases.

Conclusions: The large number of different quality criteria appearing within a relatively small number of criteria catalogs shows that the opinion of what is important in the quality of health information differs. In addition, to define useful quality criteria for websites about rare diseases, which are an essential source of information for many patients, a trade-off is necessary between the high standard of quality criteria for health information websites in general and the limited provision of information about some rare diseases. Finally, transparently presented quality assessments can help people to find reliable information and to assess its quality.

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KEYWORDS

rare diseases; self-help groups; Internet; health information exchange; quality indicators

Introduction

The European Union considers diseases to be rare when they affect no more than 5 in 10,000 people. It is estimated that there are between 5000 and 8000 different rare diseases, affecting nearly 30 million people in the European Union and 4 million people in Germany alone [1,2]. Consistent with this diversity, the quality of information available on the Web varies considerably. People searching the Web often find it very difficult to find the right information and to assess its quality [3,4]. With Orphanet [5], an information platform exists, which holds comprehensive and quality-tested information. However, the target group it addresses is potentially specialists rather than patients [6,7]. In keeping with the European Council's recommendations, Germany has published a National Action Plan for Rare Diseases in August 2013, which will guide and structure actions in the context of rare diseases within their health and social systems [8]. It includes 52 policy proposals. The national project ZIPSE (German: Zentrales Informationsportal über seltene Erkrankungen; English: Central Information Portal about Rare Diseases), initiated by the Federal Ministry of Health, deals with the realization of the plan's topics 37 to 39, which cover the subject of a central information portal [9]. Hereby, the health and well-being of people with rare diseases should be improved.

The aim of the ZIPSE project is to conceptualize and implement a central information portal about rare diseases in Germany. A centralized access point for quality-tested information appears to be very helpful for people with a rare disease, their relatives, and medical experts [9]. The portal itself does not contain primary information but refers to existing quality-assured information sources. The aim is the provision of an intelligent user guide to relevant and appropriate sources of information [10]. Web-based information and websites about rare diseases will be linked in the information portal. More precisely, a variety of quality-tested websites about rare diseases will be offered to all users. Furthermore, users will be able to search for disease-specific websites and to filter them by quality criteria. Therefore, a method to distinguish high- and low-quality websites needs to be established [10,11]. A number of quality certificates for websites dealing with medical information already exist. Websites with such a certificate demonstrate quality-tested content [3]. It can be hypothesized that existing quality certificates for websites with health information (eg, Health On the Net Foundation Code of Conduct, HONcode; DISCERN; and Stiftung Gesundheit) are rarely used by websites about rare diseases. It can be assumed that patient organizations often provide well-researched and reliable information about rare diseases, but they have limited resources in terms of time and money to present themselves as professionally as other information providers on the Web to fulfill the requirements of existing quality certificates. Furthermore, the providers' motivation to present themselves professionally is unknown. The quality control process of certificates such as HONcode can be costly and require significant effort owing to stringent requirements. Verifying websites providing medical information about rare diseases using quality criteria can help increase acceptance and signal trustworthiness to patients, relatives, and medical experts. Most existing quality certificates focused on medical information pursue different goals and contain a wide range of different types of quality criteria. Hence, specific quality criteria for websites about rare diseases are needed. The objective of this study was to generate a catalog of quality criteria suitable for rare diseases. Implementing these quality criteria will improve the evaluation and assessment of information about rare diseases for patients, health professionals, and other users of the information portal.

Methods

The method we adopted can be regarded as a process divided into 3 steps, as shown in the flowchart in Figure 1.

In step 1, a comprehensive Web search was performed to identify quality certificates and criteria catalogs for websites containing medical or health information. Although we focused on programs and catalogs active in Germany because of its implementation of the information portal about rare diseases, we considered several international sources as well. Quality certificates and criteria catalogs were only included if the quality criteria were published transparently. Furthermore, to be included the certificates and catalogs had to focus on Web-based resources containing medical or health information. Certificates, catalogs, and recommendations were therefore excluded if, for example, they focused only on printed medical information. Additionally, websites about rare diseases were analyzed to identify their quality criteria and their use of quality certificates. These criteria were added if they were not already identified through the Web search. Finally, all identified references were again checked for suitability.

In step 2, the unique criteria of each certification program and catalog were examined, extracted into an overview table, and analyzed by thematic content. Thematic correlations between the criteria were pooled together with an inductive design into major categories. Experts on rare diseases were consulted on the construction of the major categories. Finally, each criterion was assigned to one of the following major categories: thematic, technical, service, content, and legal. Where feasible, the categories were broken down further into groups of criteria. Additionally, experts on rare diseases provided opinions and general information about the importance of each criterion and critical aspects of quality criteria for information about rare diseases. If a criterion was already present in the map, it was not reentered but marked as being part of another criteria catalog. In order to evaluate the importance of a single criterion, its repeated occurrence among different criteria catalogs was examined. Criteria appearing in several catalogs were considered more important, whereas those that were part of a single catalog alone were considered less important. Thus, a hierarchy of the quality criteria appearing in the identified catalogs was

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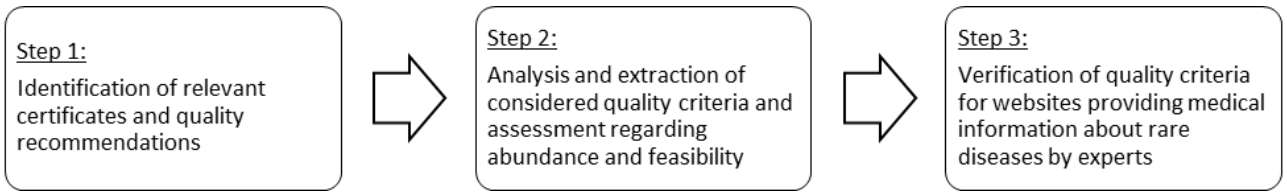
constructed, ordered from the criteria appearing the most number of times to those appearing just once.

In step 3, the most important criteria were selected by the project group as preliminary quality criteria. Next, a workshop was held with various experts on website quality and other publications with medical content, experts on health economics and medical informatics, as well as medical experts in the field of rare diseases. A total of 27 experts participated in the workshop—4 of them were professors and 12 graduate doctors. These experts were invited to participate in the group discussion about quality criteria for websites providing medical information about rare diseases. Participants did not receive incentives to attend the workshop and discussion. The relevance and applicability of each quality criterion were discussed, evaluated, and verified by the expert group. The discussion with medical experts as well as experts on the quality of medical information focused on choosing the criteria that should be mandatory for websites offering medical information on rare diseases. Input from medical experts was equally valuable as input from experts on quality of medical information. At the end of the discussion, the experts were expected to arrive at a consensus on the importance of the different quality criteria. Finally, it was decided which of the quality criteria should be mandatory for these websites to be listed on the information portal about rare diseases. Experts from the following institutions participated in the workshop and group discussion:

- German Action Forum Health Information System (afgis e.V.)
- German Alliance of Chronic Rare Diseases (ACHSE e.V.)
- Agency for Quality in Medicine (ÄZQ)
- Federal Ministry of Health Germany (BMG)
- Charité Universitätsmedizin Berlin
- Center for Health Economics Research Hannover (CHERH)
- German Cochrane Center (DCZ)
- Frankfurt Reference Center for Rare Diseases (FRZSE)
- Institute of Medical Biostatistics, Epidemiology and Informatics (IMBEI), University Medical Center Mainz
- Institute for Quality and Efficiency in Health Care (IQWiG)
- Cancer Information Service Heidelberg (KID)
- Hannover Medical School (MHH)
- National Action League for People with Rare Diseases (NAMSE)
- Orphanet Germany
- Public Health Foundation
- Department of Dermatology, Medical Center University of Freiburg
- University Medical Center Hamburg-Eppendorf (UKE)
- Centre for Quality and Management in Healthcare, Medical Association of Lower Saxony (ZQ)

Figure 1. The three steps of the analyzing procedure.



Results

Identification of Relevant Certificates

A total of 9 quality certificates and criteria catalogs for websites containing medical or health information were identified. Of these certificates and catalogs, 2 were used internationally; 7 were verified only for German websites. The most common certificate for medical information websites was identified as HONcode [12]. Three further certificates verifying only German websites were identified: afgis Qualitätslogo [13], Stiftung Gesundheit [14], and Medisuch [15]. Additionally, several German, European, and international criteria catalogs were considered: afgis Checkliste für medizinische Websites [16], DISCERN [17], Gute Praxis Gesundheitsinformation [18], NAMSE Kriterien und Standards [19], and Patientenorientierte Krankheitsbeschreibung nach ACHSE-Kriterien [20]. Lastly, the results of a study identifying the most important quality criteria for medical information websites were analyzed [21]. All identified quality catalogs are described in Table 1. Furthermore, the development of quality criteria is an ongoing process, including more detailed quality assurance whereby recent quality catalogs take into account older catalogs and quality certificates. In summary, the identified quality catalogs, certificates, and recommendations show different thematic focuses on the criteria that are considered important to ensure a high quality of health information. Moreover, Table 1 shows that the process of determining the quality of information differs among the identified providers (self-reporting audits vs publicly available information).

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Table 1. Quality catalogs and quality certificates.

Name	Description	Characteristics	Number of criteria (n=304)
NAMSE Kriterien und Standards[a] [19]	A discussion paper about quality criteria for enhancing patient information about rare diseases.	It contains requirements for the categories: creation process, results, implementation, and evaluation.	56
HONcode[b] [12]	As an international certificate, awarded by the Health On the Net Foundation located in Switzerland and established in 1995, it has held NGO[c] status at the United Nations since 2002. Since 1996, a free certificate for "trusted" sites with medical information was awarded. Since 2015, certification is provided as a paid service. The organization claims that about 8000 medical websites hold their certificate.	Its principles: Information must be authoritative—stating the qualifications of the author. Complementarity—information must supplement and help to support medical advice, not replace it. Privacy—compliance with confidentiality of personal data entered by a website visitor. Assignment—References to sources of information and dates must be present. Verifiability—treatments, products, and services must be supported by balanced, verifiable, scientific information. Transparency and contact information. Disclosure of funding—sponsorship, sponsors, and financial sources must be named. Advertising policy—separation of advertising and editorial content.	55
afgis-Qualitätslogo[d] [13]	The afgis Qualitätslogo is based on 10 quality categories for transparently provided information, whereby the verification is based on self-reporting audits.	It is based on 10 quality categories for transparently provided information: criteria for transparent information about providers, purpose and target group, authors and information sources, data release, timeliness, and planned maintenance of the information, possibility to give user-feedback, procedure of internal quality assurance, separation of advertisement and editorial contribution, financing and sponsoring, cooperation and networking, and data protection, data transmission, and use of data.	39
afgis Qualitätskriterien [16]	afgis Checkliste für medizinische Websites[e] is a guideline for providers that want to regenerate websites with medical information content.	It contains essential Web standards for the following categories: timeliness, data protection, design and navigation, medical information, legal aspects, service aspects, search engine, transparency, and access.	35
Gute Praxis Gesundheitsinformation[f] [18]	A catalog containing quality criteria for the development of health information with a requirement for evidence-based information.	It focuses on the development of health information with a requirement for evidence-based information, which is comprehensible given the expertise of the target group. Thus, the catalog contains different criteria for various target groups.	30

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Name	Description	Characteristics	Number of criteria (n=304)
Stiftung Gesundheit[g] [14]	Awards a seal of approval after checking more than 100 issues, whereby the verification is based on information that is available on the website.	It awards a seal of approval after checking criteria out of the following categories: legal quality, publishing diligence, usability, and search engine optimization.	30
Patientenorientierte Krankheitsbeschreibung nach ACHSE-Kriterien[h][20]	Contains quality criteria grouped into 5 categories.	It contains quality criteria of the following categories: creation and formal aspects, medical-scientific data and information, disease management, establishment of contact and information about specialties of health professionals, and additional links and references.	28
DISCERN [17]	A tool to evaluate medical publications with a focus on patient information.	It focuses on the following: reliability of the publication and quality of information on treatment alternatives.	19
Medisuch [15]	Provides a certification process and is operated by the institute for quality and transparency of health information.	As a part of its certification process, information providers have to declare that the information provided on the website is not influenced by industrial offers.	12

[a] NAMSE Kriterien und Standards: NAMSE (National Action League for People with Rare Diseases) criteria and standards (in English).

[b] HONcode: Health On the Net Foundation Code of Conduct.

[c] NGO: nongovernmental organization.

[d] afgis Qualitätslogo: German Action Forum Health Information System (afgis) quality logo (in English).

[e] afgis Checkliste für medizinische Websites: afgis checklist for medical websites (in English).

[f] Gute Praxis Gesundheitsinformation: good practice health information (in English).

[g] Stiftung Gesundheit: Public Health Foundation (in English).

[h] Patientenorientierte Krankheitsbeschreibung nach ACHSE-Kriterien: patient-oriented description of disease by the criteria of ACHSE (German Alliance of Chronic Rare Diseases) (in English).

Analysis and Extraction of Quality Criteria

The number of criteria present in the quality certificates is listed in Table 1. The presented number can be higher (or lower) than the official numbers stated by the providers owing to a more detailed valuation of criteria by the project group. The number of criteria ranged from 12 to 56 in the catalogs analyzed. In total, we identified 304 single criteria items. Through this, we aggregated 163 different quality criteria into 5 major categories: thematic, technical, service, content, and legal. The thematic criteria category containing 90 criteria (90/163, 55.2%) was by far the largest, followed by the service category with 26 criteria (26/163, 16.0%), the technical category with 18 (18/163, 11.0%), the legal category with 15 (15/163, 9.2%), and the content category with 14 (14/163, 8.6%). The degree of detail varied among the different criteria catalogs, and while 66 criteria (66/163, 40.5%) were found in multiple catalogs, no criterion was found in all of the certificate definitions or criteria catalogs. The 2 most frequently occurring criteria appeared in 6 of the analyzed catalogs (6/9, 67%). Three criteria appeared in 5 (5/9, 56%) and 13 criteria in 4 of the catalogs (4/9, 44%), whereas 20 criteria appeared in 3 (3/9, 33%) and 28 criteria in 2 of the catalogs (2/9, 22%). The majority of 87 criteria were unique to a single catalog. With the exception of one catalog (Gute Praxis Gesundheitsinformation), each contains a criterion unique to itself. All identified quality criteria are presented in Multimedia Appendix 1. In summary, the number of criteria present in quality certificates and quality catalogs differs. Nevertheless, most catalogs contain a unique criterion not shown elsewhere. The number of quality criteria in each of the major categories varies widely.

Expert Verification

To assess the relevance of a quality criterion specific to websites offering medical information on rare diseases, different principles were applied. First, criteria appearing in many of the reviewed catalogs were considered more important to ensure a certain level of information quality. This resulted in initially selecting the two most abundant criteria (authors are mentioned and creation and updating dates of information are mentioned) as mandatory for websites to be listed in the information portal ZIPSE. Criteria appearing less often were only selected in consideration with their relevance and their applicability to rare diseases and the targeted websites. This relevance was assessed by checking several properties. If a criterion is applicable, it is to a certain extent defined by its feasibility. Criteria seemingly

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important to the quality of general medical information may only be adapted to a limited extent. Finally, in the discussion workshop with 27 experts, quality criteria for websites offering medical information on rare diseases were defined. A consensus about the following 13 quality criteria for websites offering medical information on rare diseases was determined:

- Authoring information
- Mentioning of authors
- Mentioning of sources
- Mentioning of creation and update date
- Data security
- Declaration of evidence
- Marking of conflicts of interests
- Consideration of target group
- Evaluation of content
- Review of information
- Characteristics of the website (accessibility)
- Imprint
- Contact opportunity

A decision was made on the quality criteria that should be a mandatory requirement for websites about rare diseases for them to be listed in the information portal. As a legal requirement for all websites, an adequate *data protection concept* as well as an *imprint* is mandatory. Moreover, we identified the *creation and updating date* and the possibility to *contact the website provider* as very important categories for patients with a rare disease.

Discussion

Principal Findings

The literature review of quality catalogs, certificates, and recommendations for websites containing medical or health information showed different thematic focuses on criteria that are important for the quality of health information. Interestingly, the investigated certificates reveal a great variety of quality criteria used by the common certificates. There is also a wide range of quality criteria where the degree of detail varied among the different criteria catalogs. Furthermore, the process for determining the quality of websites differs among the identified providers (self-reporting audits, eg, [13] vs publicly available information, eg, [14]). The classification of the quality criteria into the major categories, thematic, technical, service, content, and legal, showed that the number of quality criteria in each category varies widely. The presence of a larger number of quality criteria in one category does not necessarily indicate a greater relevance of the category. It is rather an indication that this category can be investigated more thoroughly than categories with a smaller number of different criteria [12].

Defined quality criteria for websites about rare diseases were coordinated and verified by a multidisciplinary expert group to ensure the quality of the information provided. These quality criteria will be applied for registration of websites on the portal about rare diseases. Out of the 13 verified quality criteria for websites about rare diseases, 4 were identified to be mandatory for registration to the information portal. First, as a legal requirement for all websites an adequate *data protection concept* and an *imprint* are mandatory. Moreover, *creation and updating date* and *possibility to contact the website provider* were identified as very important categories for patients with a rare disease. The documentation of the creation and updating date of information is especially important owing to rapid advances in the development of information and to demonstrate the latest research findings [22]. The possibility to contact the website provider is also an important quality aspect for these websites. Particularly, if there is limited information elsewhere, patients, health professionals, and other users can offer the provider advice or suggestions for improvement or ask for more precise information about a rare disease [23]. These 4 categories are mandatory for registration to the information portal and for linking to medical information about rare diseases. Fulfillment of the remaining 9 categories is optional. Nonetheless, these categories are still important for quality-tested information about rare diseases. To achieve transparency, it would be beneficial to publish the degree to which the websites fulfill these categories. In particular, information on the characteristics of the website, such as its accessibility, is important for many patients [24]. Thus, the fulfillment of each single low-barrier criterion needs to be shown transparently.

Using quality criteria to verify websites providing medical information about rare diseases can help to improve their acceptance and signal trustworthiness to patients, relatives, and medical experts [3]. In further studies, all selected quality criteria will be transferred to a so-called self-disclosure questionnaire. These questions will then be used to assess the quality of rare disease websites. The results from the first evaluation of these can help to improve and adjust the quality assessment process of the information portal. Moreover, we can evaluate and test the assumptions made at the beginning:

- Do patient organizations provide well-researched and reliable information about rare diseases?
- Do they present themselves as professionally as other information providers on the Web to fulfill the requirements of existing quality certificates?
- Do websites with little content and a small editorial staff hold high-quality information?

A further problem for investigation is the availability of robust evidence of information on rare diseases. Providing evidence for the source of information is a requirement often sought to ensure a piece of information is well researched. However, with merely 5 in 10,000 people affected by rare diseases, it is almost impossible to collect sufficient data to statistically test a hypothesis. It could be argued that a single proven case is also a form of evidence, albeit a very thin one. However, as long as no other data exist, it is still the best evidence available [25]. There are also important implications for future research from analysis of those categories where we identified a lower number of different criteria. New detailed quality criteria on these categories may help improve the discussion on quality of websites providing medical information.

Limitations

Despite our focus on programs and catalogs active in Germany, we identified a large number and variety of different quality criteria. As with other quality catalogs, the defined criteria

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cannot verify the thematic content of health information. These criteria simply verify factors influencing the thematic content, as well as the quality of the website itself. A more complex and expensive solution to verify the heterogeneous information about rare diseases would be for medical experts to verify and highlight single articles of listed websites about rare diseases in the information portal. The defined quality criteria for such websites were verified by the participants of a workshop. Although this workshop was held with 27 renowned and excellent experts on website quality and other publications with medical content, experts on health economics and medical informatics, as well as medical experts in the field of rare diseases, subjectivity in their decision-making process cannot be ruled out.

Conclusions

The relatively low intersection of criteria appearing in the different criteria catalogs shows that the opinion of what is important concerning quality of medical information differs. For the development of useful quality criteria for websites about rare diseases, a trade-off between the high standard of quality criteria for general health information and the provision of limited existing information about rare diseases, which is essential for many patients, appears unavoidable. Providing defined quality criteria for websites about rare diseases can help seekers to find reliable information and to assess its quality [3,4]. Accepted criteria for websites with information about rare diseases, which allow for a minimum of quality control while keeping the workload reasonable, have been defined. In summary, 13 categories with quality criteria were defined by a group consisting of medical experts as well as experts on the quality of medical information. Fulfillment of 4 of these categories (*data protection concept*, *imprint*, *creation and updating date*, and *possibility to contact the website provider*) was identified as being mandatory for registration to the information portal and for publishing medical information about rare diseases. With the help of these quality criteria, we can evaluate, for instance, the quality of information provided by rare disease self-help groups or other information providers.

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Conflicts of Interest

None declared.

Multimedia Appendix 1

Quality criteria for health information websites.

[PDF File (Adobe PDF File), 563KB - ijmr_v5i3e24_app1.pdf]

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Abbreviations

ACHSE: German Alliance of Chronic Rare Diseases
afgis: German Action Forum Health Information System
BMG: Federal Ministry of Health Germany
e.V: registered society
HONcode: Health On the Net Foundation Code of Conduct
NAMSE: National Action League for People with Rare Diseases
ZIPSE: Central Information Portal about Rare Diseases

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Original Paper

Internet Use for Searching Information on Medicines and Disease: A Community Pharmacy–Based Survey Among Adult Pharmacy Customers

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Abstract

Background: The Internet is increasingly used as a source of health-related information, and a vast majority of Internet users are performing health-related searches in the United States and Europe, with wide differences among countries. Health information searching behavior on the Internet is affected by multiple factors, including demographics, socioeconomic factors, education, employment, attitudes toward the Internet, and health conditions, and their knowledge may help to promote a safer use of the Internet. Limited information however exists so far about Internet use to search for medical information in Italy.

Objective: The objective of this study was to investigate the use of the Internet for searching for information on medicines and disease in adult subjects in Northern Italy.

Methods: Survey in randomly selected community pharmacies, using a self-administered questionnaire, with open and multiple choices questions, was conducted.

Results: A total of 1008 participants were enrolled (59.5% women; median age: 43 years; range: 14-88 years). Previous use of the Internet to search for information about medicines or dietary supplements was reported by 26.0% of respondents, more commonly by women (30.00% vs 20.10% men, P<.001), unmarried subjects (32.9% vs 17.4% widowed subjects, P=.022), and employed people (29.1% vs 10.4% retired people, P=.002). Use was highest in the age range of 26 to 35 (40.0% users vs 19.6% and 12.3% in the age range ≤25 and ≥56, respectively, P<.001) and increased with years of education (from 5.3% with 5 years, up to 41.0% with a university degree, P<.001). Previous use of the Internet to search for information about disease was reported by 59.1% of respondents, more commonly by women (64.5% vs 51.0% males, P<.001), unmarried subjects (64.2% vs 58.5% married or divorced subjects and 30.4% widowed subjects, P=.012), unemployed people (66.7% vs 64.0% workers and 29.9% retired people, P<.001). Use was highest in the age range of 26 to 35 (70.1% vs 64.4% in both 36-45 and 46-55 ranges and 35.1% in ≥56, P<.001) and increased with years of education (from 12.5% with 5 years up to 66.7% with 13 years and 68.6% with a university degree, P<.001). Retrieved information was rated as satisfactory by about 87.5% (88.1% women and 86.2% men, P=.562). Recent use of medicines or dietary supplements was associated with more frequent use of the Internet to search for disease and drugs.

Conclusions: The study provides detailed information on the use of the Internet for searching for information on medicines and disease in the Italian population. Gender, age, social status and level of education, and the previous use of medicines, affect searching behaviors and use patterns. Results can support educational interventions to promote the retrieval of high-quality information by Internet users and health professionals advising patients about appropriate use of Internet for health-related purposes.

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KEYWORDS

Internet; health information; information searching behavior; medicines; diseases; survey

Introduction

The Internet is currently a major source of health- and medical-related information. People using the Internet for health-related searches are estimated to be up to more than 70% of Internet users in both the United States [1,2] and Europe [3]. In particular, the European survey, including 7 countries (Norway, Denmark, Germany, Greece, Poland, Portugal, and Latvia) and a total of 7934 respondents reported percentages of Internet users searching for health-related information in the range of 30% to 62% of the total sample (and 54%-79% of total Internet users) with wide differences among countries [3].

Specific diseases or health-related problems are acknowledged as the main determinants in deciding to search for medical information on the Internet; however, health information searching behavior on the Internet is affected by multiple factors, including demographics, socioeconomic factors, education, employment, attitudes toward the Internet, and health conditions [1-3]. Knowledge of such factors may allow the promotion of a safer use of the Internet for health purposes, also in consideration of potential dangers such as the dissemination of inaccurate information and the inappropriate use [4-6]. The Internet has indeed an enormous potential for health promotion, which however requires the development of a critical usership and the collaboration of health care professionals [7]. To meet such requirements, detailed knowledge of Internet contents (eg, [8,9]) and of the attitudes of their users is mandatory.

The use of the Internet to search for medical information in Italy has received so far limited attention, in a few specific populations, such as amyotrophic lateral sclerosis patients and caregivers [10], and pregnant women [11,12], and concerning specific issues, such as chronic obstructive pulmonary disease patients' knowledge regarding cardiopulmonary resuscitation [13]. Only 1 survey currently exists addressing the extent of Internet use to retrieve medical information in a sample of adults selected among parents of public school students in Southern Italy [14].

Objectives

The objectives of this study were to investigate the use of the Internet for searching for information on medicines and disease in a sample of adult subjects recruited among pharmacy customers in Northern Italy, with particular regard to personal use of medicines and dietary supplements and individual attitudes toward the use of the Internet for the purchase of goods, to provide evidence about the association between Internet use and specific factors (eg, age, gender, employment, and so forth). Italian pharmacies have a monopoly on prescription medications. In addition, they sell over-the-counter medications and nonmedical products such as cosmetics, medical devices, dietary supplements, special foods (for people with diabetes, coeliac disease, and so forth). Italian pharmacies do not deal with many nonmedical items (eg, beverages, food, magazines, wrapping paper and household items, and so forth). Pharmacy customers in Italy are therefore highly likely to have specific medical or health problems regarding themselves, their relatives, and so forth.

Methods

Participants

This survey was carried out from October 2010 till July 2011 in 5 randomly selected community pharmacies in the province of Como, in Northern Italy. Participants were pharmacy customers who were approached consecutively and invited to participate in the study when fulfilling the following inclusion criteria: being aged ≥18 years, giving written informed consent.

Questionnaire

Persons who agreed to participate filled out a self-administered questionnaire (Multimedia Appendix 1), with open and multiple choices questions, structured into 3 sections devoted to the collection of the following data:

1. Sociodemographic: age, gender, level of education, employment, and marital status.

2. Use of medicines and dietary supplements in the previous 6 months.

3. Internet use: searching of information about disease, medicines, dietary supplements, attitudes toward Internet purchase of goods in general, of medicines, and of dietary supplements.

Analysis

Collected data were recorded into a digital archive (Microsoft Excel). Drugs were classified according to the World Health Organization (WHO) Anatomical Therapeutic Chemical Classification System, whereas diseases were classified according to the WHO International Statistical Classification of Diseases, Injuries and Causes of Death, 10th Edition. Records were validated according to the International Quality Standard ISO 2859 guidelines (ISO 2859-4:2002), and the database was considered suitable for analysis. Before the analysis, each record was checked for intrasection and intersection coherence. Statistical approach was based on distribution of responses. Gaussian distribution was checked by means of the D'Agostino and Pearson omnibus normality test. Proportions were compared using chi-square analysis, and means were compared using Student's *t*-tests. Odds ratios and corresponding 95% CIs were obtained using the Woolf logit method. Analyses were performed using a commercial software (GraphPad Prism version 5.00 for Windows; GraphPad Software, San Diego, CA, USA).

Results

Participants

The survey enrolled a total of 1008 participants. Their demographic details are shown in Table 1. The median age was 43 years (interquartile range: 34-51), with a range of 14 to 88

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years. Most of the participants were married or cohabiting (61.8%) or single (30.3%), with no differences between women and men. Nearly 70% of the participants had secondary school or university degrees. University degrees were declared more frequently by women than men (26.0% vs 19.4%). Nearly 73% of respondents were employed, and 10% were retired. In comparison to women, men were more likely to be employed (79.5% vs 68.1%) or retired (13.7% vs 7.5%), whereas women were more likely to be unemployed (2.6% vs 0.7%) and housewives (15.2% vs 0.0%).

Table 1. Demographics of participants in the survey.

Item	Total (%)	Female (%)	Male (%)	*P* [a]
	1008 (100)	600 (59.5)	408 (40.5)	
Age (years)[b]				
Mean standard deviation	43.3 13.9	42.6 13.8	43.8 14.0	.999
Age distribution				.169
≤25	105 (10.6)	66 (11.1)	39 (9.8)	
26-35	168 (17.0)	109 (18.4)	59 (14.9)	
36-45	299 (30.2)	186 (31.4)	113 (28.5)	
46-55	249 (25.2)	142 (23.9)	107 (27.0)	
≥56	168 (17.0)	90 (15.2)	78 (19.7)	
Marital status[c]				.100
Single	296 (30.3)	183 (31.5)	134 (33.8)	
Married or cohabiting	603 (61.8)	356 (61.4)	247 (62.4)	
Separated or divorced	54 (5.5)	22 (3.8)	11 (2.8)	
Widowed	23 (2.4)	19 (3.3)	4 (1.0)	
Education (years)[d]				.004
5	41 (4.3)	31 (5.5)	10 (2.5)	
8	249 (26.0)	131 (23.3)	118 (29.7)	
13	445 (46.4)	253 (45.1)	192 (48.4)	
>13	223 (23.3)	146 (26.0)	77 (19.4)	
Employment[e]				<.001
Yes	717 (72.7)	399 (68.1)	318 (79.5)	
No	18 (1.8)	15 (2.6)	3 (0.7)	
Retired	99 (10.0)	44 (7.5)	55 (13.7)	
Student	63 (6.4)	39 (6.7)	24 (6.0)	
Housewife	89 (9.0)	89 (15.2)	0 (0.0)	

[a]Women versus men.

[b]Missing answers: 19.

[c]Missing answers: 32.

[d]Five years correspond to completion of primary school, 8 to secondary school, 13 to high school, more than 13 indicate enrollment into a university course. Missing answers: 50.

[e]Missing answers: 22.

Information on Medicines

Overall, of 991 respondents, 258 (26.0%) reported previous use of the Internet to search for information about medicines or dietary supplements. Use of the Internet for this purpose was much more common among women in comparison to men (30.0% vs 20.1%, *P*<.001), and it was highest in the age range of 26-35 and lowest in the age range of ≤25 and ≥56 (40.0% users vs 19.6% and 12.3%, respectively, *P*<.001). Higher use was reported by unmarried subjects in comparison to widowed subjects (32.9% and 17.4%, respectively, *P*=.022) and by people with an employment in comparison to retired people (29.1% and 10.4%, respectively, *P*=.002), and use increased with years of education (from 5.3% with 5 years up to 41.0% with a university degree, *P*<.001).

Respondents most frequently searched for information on the following medications: central nervous system (CNS) drugs

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(22.3%), gastrointestinal drugs (17.9%), musculoskeletal drugs (15.2%), antibiotics (10.7%), genitourinary system drugs, and sex hormones (9.8%), antitumor drugs (6.2%), hormones and drugs for the respiratory system (5.4% each).

Among dietary supplements, information most frequently searched was about products containing minerals, vitamins, amino acids or proteins (20.9%), products for sport activities (13.4%), for menopause (9.0%), for body weight (7.5%), and cholesterol and for digestive tract (6.0% each).

Retrieved information was rated as satisfactory by 89.2% among both women and men.

Of 999 respondents, 684 (68.5%) were aware of the possibility to purchase medicines on the Internet (65.0% women vs 73.5% men, *P*=.005), and awareness increased with age (from 41.7% at ≤25 up to 76.6% at 46-55, *P*<.001). Awareness was higher in married or divorced subjects in comparison to widowed subjects (73.3%, 72.2%, and 47.8%, respectively, *P*<.001) and in people with an employment in comparison to people without an employment and to students (71.3%, 55.6%, and 55.6%, respectively, *P*=.026), and awareness increased with years of education (from 45.0% with 5 years up to 76.2% with 13 years or more, *P*<.001).

Only 9.2% of respondents had a positive opinion about purchase of medicines on the Internet (6.1% women vs 15.9% men, *P*=.001).

Possibility to purchase dietary supplements on the Internet was known by 70.3% of respondents (67.7% women vs 74.0% men, *P*=.039), and awareness increased with age (from 50.5% at ≤25 up to 75.9% at 46-55, *P*<.001), and it was rated as positive by only 13.2% (12.2% women vs 14.7% men, *P*=.430). Awareness was higher in married or divorced subjects in comparison to widowed subjects (72.3%, 75.0%, and 39.1%, respectively, *P*=.005) and in people with an employment in comparison to people without an employment (73.6% and 55.6%, respectively, *P*=.024), and awareness increased with years of education (from 42.5% with 5 years up to 81.9% with 13 years or more, *P*<.001).

Information on Disease

Previous use of the Internet to search for information about disease was reported by 590 of 999 respondents (59.1%). More women than men used the Internet for this purpose (64.5% vs 51.0%, *P*<.001). Use of the Internet to search for information about disease was highest in the age range of 26-35 (70.1%) and 36-45 and 46-55 (both, 64.4%) and lowest in the age range of ≥56 (35.1%, *P*<.001). Highest use was reported by unmarried subjects (64.2%), followed by married or divorced subjects (58.5%), and widowed subjects declared the lowest use (30.4%, *P*=.012). Higher use was reported by people without an employment (66.7%), followed by workers (64.0%), and lower use by retired people (29.9%, *P*<.001). Use increased with years of education (from 12.5% with 5 years up to 66.7% with 13 years and 68.6% with a university degree, *P*<.001).

Most of the respondents (32.9%) declared that they sought information on several unspecified disease. Specified diseases most commonly sought were: cancer (19.0%), CNS disease (11.6%), infectious disease (10.5%), musculoskeletal disease (10.1%), gastrointestinal disease (9.5%), endocrine and metabolic disease (8.3%), cardiovascular disease (7.7%), genitourinary system disease (6.6%), skin disease (6.4%), traumatic disease and intoxication (4.3%), respiratory disease (4.1%), mental and behavioral disturbances (2.7%), abnormal laboratory results (1.5%), hematopoietic disease (1.2%), and ocular disease, ear disease, pregnancy and partum, malformations (all less than 1.0%).

Retrieved information was rated as satisfactory by about 87.5% (88.1% women and 86.2 men, *P*=.562).

Relationship With Previous Use of Medicines or Dietary Supplements

Respondents who reported use of medicines or dietary supplements in the previous 6 months made more frequent use of the Internet to search for both disease and drugs (Table 2).

Table 2. Relationship between Internet use for information on medicines and disease and previous use of medicines or dietary supplements.

Use in the last 6 months	Looked for information on Internet							
	Disease		Odds Ratio (95% CI)	*P*	**Medicines/ dietary supplements**		Odds Ratio (95% CI)	*P*
	Yes, n (%)	No, n (%)			Yes, n (%)	No, n (%)		
Medicines								
Yes (n=788)	477 (60.5)	304 (38.6)	1.40 (1.02-1.92)	.041	218 (27.7)	560 (71.1)	1.70 (1.14-2.54)	.009
No (n=195)	102 (52.3)	91 (46.7)			35 (17.9)	153 (78.5)		
Dietary supplements								
Yes (n=788)	249 (65.5)	130 (34.2)	1.57 (1.20-2.05)	<.001	133 (35.0)	243 (63.9)	2.17 (1.62-2.90)	<.001
No (n=195)	330 (54.3)	271 (44.6)			120 (19.7)	476 (78.3)		

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Discussion

Principal Findings

The results of the present survey, involving more than 1000 participants in Northern Italy, show that the use of the Internet to search for information on medicines and disease is widespread, however, to a different extent. Nearly 60% of respondents used the Internet to search for information about disease, while previous use of the Internet to search for information on medicines or dietary supplements was reported by only 26% of respondents. The only survey so far available in the Italian population was published in 2013 and reported about 53% adult people using the Internet to retrieve information about drugs and between 70% and 86% about disease diagnosis and treatment [14]. Such survey was conducted among parents of public school students, whereas our survey recruited pharmacy customers. As a consequence, the former might have overestimated the frequency of healthy subjects while excluding elderly people, whereas the present survey might have included more people with health problems. Both of them therefore might not precisely estimate Internet information searching in general among all adults. Further implications of the sampling strategy are discussed below (see “Limitations”).

Despite the aforementioned huge difference between Internet searching for disease and drugs, the profile of information searchers was similar: searching for health-related information on the Internet was more common among women in comparison to men, in the age range of 26-35, among unmarried subjects and employed people and increased with years of education, being highest in those with a university degree. In addition, use of medicines or dietary supplements in the previous 6 months increased the odds of Internet use to search for both disease and drugs. On the contrary, the use of the Internet for such purposes was lower in men, in the age range of ≤25 and ≥56, as well as among widowed subjects or retired people, and in people with only a few years of education. The profile of information searchers is in agreement with those of previous reports showing that characteristics associated with Internet use for health-related information included being younger, women, having a higher level of education, and suffering for chronic conditions [14-16]. Indeed, in our study, use of medicinal products in the previous 6 months can be considered as a proxy for both acute and chronic health problems.

Most searched diseases were cancer and CNS disease, followed by infectious disease, musculoskeletal disease, and gastrointestinal disease. Among searched medicines, CNS drugs ranked first; however, antitumor drugs ranked only seventh, after gastrointestinal drugs, musculoskeletal drugs, antibiotics, genitourinary system drugs, and sex hormones, suggesting the lack of any direct correlations between the perceived need for information on disease and medicines. It is likely that different personal factors play a role in deciding to search for information about medicines and about disease, and this issue might deserve further attention in future studies.

Dietary supplements most frequently sought were: minerals, vitamins, amino acids, and products for sport activities in general, followed by products for menopause and body weight. This is in agreement with recent marketing data, showing that in Italy, dietary supplements are increasingly used not only for disease prevention but also for performance enhancement, and that use of dietary supplements for disease prevention is more common about elderly subjects and in particular among women [17].

According to our results, about 70% of the respondents were aware of the possibility to purchase medicines or dietary supplements on the Internet. Interestingly, people aware of this possibility were mainly men, and awareness increased with age and with years of education. Although education is a well-known strong predictor of access to the Internet [18], and in this survey, it was associated, together with female gender and younger age, also with the use of the Internet for searching for information about disease and medicines, male gender and age seem to be specific for the knowledge about the use of the Internet for purchasing purposes. Indeed, different attitudes and perceptions have been reported for women and men with regard to purchasing goods and services on the Internet [19]. Anyway, it must be emphasized that, at the time of this survey, in Italy, it was not possible to purchase medicines on the Internet, and this could also well explain the usually negative opinion expressed by more than 90% of the respondents about purchase of medicines on the Internet. Remarkably, in this regard, women were even more negative than men.

Italy was not among the European countries surveyed in the study by Andreassen et al [3]. In the study, factors positively associated with the use of the Internet for health purposes were young age, female gender, higher education, white-collar or no paid job, visits to the general practitioner during the past year, long-term illness or disabilities, and a subjectively perceived good health [3]. In our survey, factors affecting Internet use for health purposes were female gender, unmarried condition, employed people, age range of 26-35, and higher education. We did not investigate factors such as visits to the general practitioner, presence of illness or disabilities, or subjective perception of one's own health. Comparison of results shows however that although some factors may exert similar roles (eg, female gender, higher education), others may differ depending on the specific context, further supporting the need for focused research.

Limitations

The main limitation of this study is that it was performed in Northern Italy, and therefore, it might not represent all the Italian population. Furthermore, the sample was recruited among pharmacy customers, potentially leading to a selection bias toward people preferentially purchasing medicines through conventional means. The surveyed population, compared with the general population of Italy [20], probably oversampled women (59% vs 51%), undersampled people aged ≤35 years (28% vs 36%) and ≥56 (17% vs 33%), and oversampled people aged 36-55 years (55% vs 31%). Moreover, in our sample, the proportion between married or cohabiting people and single people was 2:1, whereas in the general population, it is nearly 1:1 [20]. Such differences must be taken into account.

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Conclusions

The present investigation provides detailed information on the use of the Internet for searching for information on medicines and disease in the Italian population. The Internet is among the main sources of health- and medical-related information, with an increasing number of Internet users searching for health-related information in the absence of any medical or expert supervision or advice. It is therefore of paramount importance to assess information searching behaviors and patterns, as well as the relevant associated factors, to allow the promotion of a safer use of the Internet for health purposes. Our study provides evidence about the role of gender, age, social status, and level of education, together with details on the health-related topics most commonly sought and their relationship with the previous use of medicines. Such results can be used to support educational interventions aimed at improving the ability of Internet users to select and preferentially retrieve high-quality information, as well as the ability of health professionals to assist and advise their patients about the appropriate use of Internet for health-related purposes.

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Both authors equally contributed to study conception and design as well as to analysis and interpretation of data. SL was responsible for acquisition of data. Both authors were involved in drafting the paper and revising it critically for important intellectual content and approved the final version to be published. Both authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was presented by SL in her thesis for the attainment of the PhD Degree in Clinical and Experimental Pharmacology, University of Insubria (XXV Cycle). No funding was received for this work.

Conflicts of Interest

None declared.

Multimedia Appendix 1

[PDF File (Adobe PDF File), 60KB - ijmr_v5i3e22_app1.pdf]

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Abbreviations

CNS: central nervous system
WHO: World Health Organization

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Original Paper

Japanese Consumer Perceptions of Genetically Modified Food: Findings From an International Comparative Study

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Abstract

Background: Reports of food-related incidents, such as cows infected with bovine spongiform encephalopathy (2001) and the Fukushima nuclear accident (2011), engendered significant fear among Japanese consumers and led to multiple farmer suicides, even when no actual health damage occurred. The growing availability of genetically modified (GM) food is occurring against this backdrop of concern about food safety. Consumers need information to assess risk and make informed purchasing decisions. However, we lack a clear picture of Japanese consumer perceptions of GM food.

Objective: This study aims to understand Japanese consumer perceptions of GM food for risk communication. Consumer perceptions of GM food were compared among 4 nations.

Methods: A Web-based survey was conducted in Japan, the United States, the United Kingdom, and France. Participants were asked about demographics, fear of health hazards, resistance to GM and breeding-improved products, perception of GM technology and products, and willingness to pay. Multiple linear regression analyses were conducted, as were *t* tests on dichotomous variables, and 1-way analysis of variance and post hoc tests.

Results: Of 1812 individuals who agreed to participate, 1705 (94%) responded: 457 from Japan and 416 each from France, the United States, and the United Kingdom. The male/female and age group ratios were all about even. Some resistance to GM food was seen in all countries in this study. France showed the strongest resistance (P<.001), followed by Japan, which had stronger resistance than the United States and the United Kingdom (P<.001). Overall, females, people in their 60s and older, and those without higher education showed the greatest resistance to GM food. Japan showed stronger fear of food hazards than other nations (P<.001, odds ratio=2.408, CI: 1.614-3.594); Japanese and French respondents showed the strongest fear of hazards from GM food (P<.001). Regarding perceptions of GM technology and products, consumers in nations other than Japan would accept GM food if it were appropriately explained, they were provided with scientific data supporting its safety, and they understood that all food carries some risk. However, Japanese consumers tended to accept GM technology but rejected its application to food (P<.001). Of those willing to purchase GM food, consumers in Japan required a discount of 30% compared with about 20% in other nations.

Conclusion: All consumers in our study showed resistance to GM food. Although no health hazards are known, respondents in Japan and France strongly recognized GM food as a health risk. Price discounts of 30% and GM technology may be communication cues to start discussions about GM food among Japanese consumers. Although education-only risk communication generally is not effective, such an approach may work in Japan to help consumers better understand GM technology and, eventually, GM food. The gap between accepting GM technology and rejecting its application to food should be explored further.

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KEYWORDS

genetically modified food; Japan; perception; health; risk

Introduction

Background

Advances in recombinant DNA technology have led to the growing worldwide availability of genetically modified (GM) food. However, consumer acceptance of GM food in Japan and in Western countries remains low. Previous studies reveal the following concerns among consumers about the possible effects of GM food: health hazards from consuming GM food, including long-term effects, negative ecological impacts, effects on future generations, and limited purchasing options that may result from uncontrolled dominance of GM food [1-5]. On the other hand, consumers also consider the possible advantages of GM food, such as helping to keep down the overall cost of food, reduced waste, and longer shelf life [1,4]. In addition, some studies indicate that trust and other emotions influence perceptions of GM food [6-8]. Under these circumstances, it is important to know consumers' perceptions and acceptance of GM food so that risk communication can effectively influence purchasing behaviors and help consumers make well-informed decisions [9-13].

In Japan, Tanaka [14] reported that Japanese people have negative feelings or attitudes toward GM food. Imamura et al [5] have led a series of government-funded studies of the public acceptance of GM food since 2009. s in studies of GM food in Western developed nations, the researchers used mass media trends as an index of public acceptance, held a focus group with consumers who have resistance to GM products overall, and conducted a Web-based survey on GM products that included a comparison between GM food and other food. Their results indicate that about 70% of the Japanese consumers surveyed did not want to eat GM food and had lower acceptance of GM food compared with food containing natural toxins and additives. Contrary to the reports by Tanaka [14] and Imamura et al [5], some studies reported that GM food was more accepted in Japan and the United States than in European countries [2,15].

Furthermore, it seems that consumer resistance to GM food may stem from uncertainty and/or unwarranted concern associated with GM technology and its use in the production of GM food [16-19]. People usually seek to reduce their uncertainty by gathering information and trying to better understand the issue of concern [20]. However, it seems that Japanese consumers do not demonstrate such attitudes [5] and a different explanation may apply. In the case of Japanese consumers, when unexpected information is given, that information may actually increase rather than decrease their uncertainty [21]. Or, they may create certainty by making up their minds about issues/products based solely on certain confirmed information and may be reluctant to communicate any remaining uncertainties [9,22]. Furthermore, when information is too complicated to understand, Japanese people tend to think based on their preexisting attitudes rather than on newly acquired information [23].

From a cultural perspective, uncertainty can be viewed as a cultural trait in response to risk and ambiguity [24]. People with low levels of tolerance for ambiguity have high levels of uncertainty avoidance and a desire for clear answers and solutions. In contrast, people with high tolerance for ambiguity have low uncertainty avoidance and tend to accept ambiguous answers and shades of gray [25]. One study reports that, even for countries as a whole, high uncertainty avoidance is negatively correlated with risk taking and positively correlated with fear of failure; France and Japan are included in the high uncertainty avoidance group, whereas the United States and the United Kingdom are in the low uncertainty avoidance group. Countries with high uncertainty avoidance tend to display emotion more than countries with low uncertainty avoidance [26]. At the same time, Japan places a high importance on social balance and harmony, is group oriented (collectivism), and discourages verbal communication in formal situations. These cultural traits mean that Japanese people tend to accept verbal ambiguity during communication and generally refrain from expressing personal opinions or attitudes [27,28]. Therefore, we believe that there may be a cultural predisposition that may influence Japanese consumers' ability or willingness to accept GM foods.

Focus of This Study

Evidence regarding Japanese consumer attitudes is mixed, making it difficult to understand their perceptions of GM food. Consumer risk perceptions are influenced and created by scientific evidence and experts' opinions, as well as social, economic, political, and psychological factors [8-13,29,30]. Risk communication that disseminates information without first recognizing the nature of the public's risk perception is likely to be pointless and ineffective.

This study aims to illustrate the distinctive traits of Japanese consumer perceptions of GM food. Taking into consideration that consumer concerns vary for different kinds of food hazards [31], the authors expected to obtain useful data regarding public perceptions of GM food in comparison with consumers in other nations. The Western nations in our study have each conducted studies of their own consumer perceptions, including some international comparative studies of consumer perceptions of GM food [2,15,19]. Only 2 of these studies included Japan in their comparisons. Furthermore, no international investigations and comparisons to understand Japanese consumer perceptions and attitudes have been done since 2001, when labeling of all GM food on the market became a legal requirement in Japan [32]. The outcomes in this study are therefore useful not only for Japan but also for all countries that participated in this study of consumer perceptions of GM food, as well as other countries with cultures similar to Japan's.

Research Framework and Hypotheses Development

In this research, the authors applied the elaboration likelihood model (ELM) [23] of attitude change. In this theory, motivation

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and ability are both required for someone to evaluate an issue. If the person's motivation and ability are high, the "elaboration likelihood" is also high that the person will think about the issue in depth. Information that deeply concerns the person is repeatedly processed and stored in long-term memory (central route). Favorable cognitive responses will be elicited only if the message arguments are compelling for the recipients.

If, on the other hand, the message arguments are not compelling (ability and motivation are low), people may need to have the information early or be reminded by communication cues, such as earning potential, attractive information sources, and situational stimuli. If the public does not have much prior information about the perceived issue, or if the issue does not have much personal relevance, it will be necessary for people to constantly be reminded by the previously mentioned communication cues (peripheral route). If this approach is successful, the information is nevertheless likely to be temporary and short lived. However, such a short-term choice/opinion change may create dissonance within the person, who will become motivated to think about a different choice/opinion and create bolstering cognitions that then may lead to a more permanent change in attitude.

A previous study [33] suggested that ELM may be useful to elicit determinants of effective risk communication. Although ELM did not predict attitude change, this theory could nevertheless be used as a tool to understand consumers' information processing [34]. Taking into consideration the ELM theory and previous study results, this study adopts ELM as a framework from which to examine and understand consumers' perceptions, including their ideas, beliefs, and ability to take in information as a result of how they understand GM food.

In line with previous studies of resistance to GM organisms [3,15], Tanaka [14] and Imamura et al [5] also found that Japanese consumers may not clearly understand the multiple benefits and risks of GM food. Furthermore, even though Japanese consumers are not fully informed about GM food, they have a strong resistance to it, and the authors speculated they might be particularly concerned about health hazards from GM food that have yet to be identified [5]. Tanaka [14] reported that only demographic factors of gender and age are related to the attitudes of Japanese people toward GM food. Perception and acceptance of GM technology vary depending on its use; in the EU nations and the United States, medical use of GM technology may be more strongly supported than its use in agriculture [35]. Based on this information and using ELM as a framework, we propose the following hypotheses about the perceptions of Japanese people toward GM food: (H1) only age and gender are related to attitudes toward GM food in Japan; (H2) fear of health hazards, as a personal relevance, disturbs the intent to understand GM; (H3) the label breeding-improved product is more acceptable than GM food; (H4) consumers have strong resistance to GM food; (H5) consumers have strong resistance to GM technology; and (H6) consumers do not have the intent to understand GM food.

This study was conducted with the approval of the Ethics Committee of Nara Medical University (authorization code: 655).

Methods

Data Collection

This study targeted consumers in 4 nations: Japan, the United States, the United Kingdom, and France. These countries were selected due to their stances on GM food, as shown clearly at the second session of the CODEX ad hoc intergovernmental task force on foods derived from biotechnology in March 2001; the United States was in favor, France was opposed, and the United Kingdom and Japan were neutral (CODEX, ALINORM01/34A).

A Web-based survey was carried out by the Internet research company Macromill Inc and Tokyo from April 20 to May 14, 2013. The company recruited 38,588 people who lived in each country and had registered as monitors; these monitors had participated in various other Web-based marketing research studies and represented diverse regions within each country. This Web-based company distributed the questionnaire through emails to monitors who indicated they would respond. Since the younger 20s generation showed a lower response rate in previous GM-related surveys in Japan [5], the recruiting email and survey questionnaire were distributed only to monitors 30 years and older in this study. To prevent spamming, invalid responses and fake registrations, the company conducts quality control reviews of each monitor's information once a year.

Participants were stratified into 4 age groups: 30s, 40s, 50s, and 60s and older in each country. For the duration of the study, the company distributed the questionnaire to arrive at the target number of 400-450 in each age group.

The questionnaire was developed by the authors and administered after conducting a pilot study, applying exploratory factor analysis (EFA) and confirmatory factor analysis (CFA); this questionnaire has been used several times in other research in Japan [5]. Although this study focused on GM food, we intentionally included items in the questionnaire about other GM products as filler items to avoid boredom and automatic responses. "Consumers" in this paper means people who are not experts in GM technology and GM food; experts were excluded when recruiting participants. The questionnaire included general questions, such as "do you usually mind seeing GM products when you go grocery shopping?" to learn about respondents' basic perceptions of GM food.

After collecting the questionnaire, EFA and CFA were conducted to ensure that the factor division was appropriate. For the statistical analysis, multiple linear regression analyses were exploratively conducted, and *t* tests were conducted on dichotomous variables. One-way analysis of variance (ANOVA) and post hoc tests (Tukey) were conducted when appropriate. The effect size was examined and the CI was set at 95%. How fear of GM food is related to consumers in the participating countries was examined by chi-square test and odds ratio. SPSS, version 22 and SPSS AMOS version 24 (IBM SPSS Statistics, Tokyo, Japan) were used for data analyses.

Questions were grouped in 7 main categories based on EFA and CFA: (1) demographics, (2) fear of health hazards, (3) resistance to GM products, (4) resistance to breeding-improved

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products, (5) interest in scientific explanations regarding GM technology and products, (6) intention to understand GM technology and food, and (7) willingness to pay (WTP).

Fear of Health Hazards

This category consisted of questions directly related to self in terms of ELM's description of perceived relevance. We included factors that actually pose health risks, such as food poisoning, norovirus, radioactive materials, bovine spongiform encephalopathy (BSE), trans fatty acids, dioxin, acrylamide, and methylmercury. GM food was on this list even though GM food has not been documented as a risk to health. The degree of fear was rated using a 6-point Likert Scale, from 1 "not afraid at all" to 6 "very afraid."

Resistance to GM Products

This category was indirectly related to self, according to ELM's perceived relevance because in these cases consumers can exercise choice. The following 10 GM products were listed: GM salmon that grows twice as fast as traditional salmon; GM shining killifish, whose bodies shine like tropical fish; GM blue roses; GM hay fever-alleviating rice, which reduces symptoms with continuous consumption; GM herbicide-tolerant crops; GM pest-resistant crops; GM nutrient-enriched crops (vitamin C, and so forth); GM drought-tolerant crops; GM cold weather-tolerant crops; and GM rapid-grow apples that grow quickly and are picked from trees earlier than regular apples. The participants were asked to rate their degree of resistance using a 6-point Likert Scale, from 1 "very strong resistance" to 6 "no resistance at all."

Resistance to Breeding-Improved Products

This category was created to compare with the resistance to GM products using the same items; the only difference is the use of the term "breeding-improved" instead of "GM," as in breeding-improved salmon and breeding-improved herbicide-tolerant crops. The participants were asked to rate their degree of resistance using a 6-point Likert Scale, from 1"very strong resistance" to 6 "no resistance at all."

Interest in Scientific Explanation of Genetically Modified Technology and Products

To understand Japanese consumers' interest in scientific explanations regarding GM technology and products, this category included statements like "most consumers would accept GM food if provided with scientific data supporting its safety." The degree of agreement or disagreement was measured using a 6-point Likert Scale, from 1 "strongly agree" to 6 "strongly disagree."

Intention to Understand Genetically Modified Technology and Food

This category was used to identify consumers' intention to understand GM technology and GM food by eliciting agreement/disagreement with statements, such as "most consumers are not aware of risks to food safety," "If provided with an explanation of genetically modified technology, most consumers would accept GM food," and "It is annoying to repeatedly hear the same argument about the safety of GM food." These questions were included to determine whether emotion and social frame influence Japanese consumers' perception and attitudes [26]. The degree of agreement or disagreement was measured using a 6-point Likert Scale, from 1 "strongly agree" to 6 "strongly disagree."

Willingness to Pay to Measure Resistance to Genetically Modified Food

Although we expected that data obtained from the previously mentioned questions would give us meaningful insights, we considered that a different angle of approach, such as WTP, might yield unexpected findings. The following products were listed in the questionnaire: GM canned corn, GM corn flakes, tomato grown with GM-corn fertilizer, GM chicken thighs, chicken thighs grown with GM-corn feed, wine fermented with GM yeast, and GM blue rose. For the WTP questions, the average market-list prices for non-GM products were indicated in the appropriate currency for each of the 4 countries surveyed. In each country, the average market list price was set as 1, and the ratio of WTP was measured and then compared among countries.

Results

Data Collection

Reliability of the questionnaire was examined by Cronbach alpha (.880). EFA and CFA were conducted: EFA indicated factors as in (1) fear of health hazards, (2) resistance to GM products, (3) resistance to breeding-improved products, (4) interest in scientific explanations of GM technology and products, (5) intention to understand GM technology and food; CFA showed a high goodness of fit (CFI=.962, GFI=.921, AGFI=.906, RMSEA=.046).

Out of 38,588 recruiting emails distributed, 1812 recipients (approximately 5%) agreed to participate and 1705 (94%) completed questionnaires were collected. The number of responses from each country was as follows: 457 from Japan, 416 from the United States, 416 from the United Kingdom, and 416 from France. The ratio of male-to-female respondents was approximately 1:1 for all participating countries. The percentage of respondents in their 30s, 40s, 50s, and 60s and older was approximately 25% for each age group. Almost all participants had jobs outside the food industry.

Because education systems varied among the participating countries, we categorized educational attainment as received/did not receive a university education. The ratio of respondents with/without a university education was, respectively, 53% to 47% in Japan, 47% to 53% in the United States, 64% to 36% in the United Kingdom, and 63% to 37% in France. The ratio of having children (0-19 years old) was 34%, 27%, 30%, and 34% in Japan, the United States, the United Kingdom, and France, respectively. Median household income was in the range of 6 million yen in Japan, 50 thousand dollars in the United States, 20 thousand pounds in the United Kingdom, and 30 thousand Euros in France. Respondents who answered that he/she does not want to answer accounted for an all-country average of 10% (16%, 6%, 8%, and 10% in Japan, the United States, the United Kingdom, and France, respectively; Table 1). Although the respondents choosing "do not want to answer"

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are included in the data, a reduction of responses of about 10% might bias the results. Furthermore, converting household income to a single currency, such as US$, would have created biases based on fluctuating exchange rates and different commodity prices in each country. Purchasing-power parity was taken into consideration, but income in different currencies and countries cannot be simply compared because income is influenced not only by amount but also by varying subsidies, such as health insurance, child support, and educational support. Household income was therefore excluded from further data analyses. In the multiple linear regression analyses, having children did not show significance in most questions.

Table 1. Demographics of the investigated countries.

Participants and Demographics	Japan	United States of America	the United Kingdom	France	Total
Agreed to participate	n=481	n=448	n=434	n=449	n=1,812
Recruitment rate (%)	24.7	2.6	3.6	6.0	4.7
Valid	n=457	n=416	n=416	n=416	n=416
Response rate (%)	95.0	92.9	95.9	92.7	94.1
Demographics					
Gender (%)					
Male	47.0	50.0	50.0	50.0	49.2
Female	53.0	50.0	50.0	50.0	50.8
Age (%)					
30s	21.9	25.0	25.0	25.0	24.2
40s	26.7	25.0	25.0	25.0	25.5
50s	26.0	25.0	25.0	25.0	25.3
60s and older	25.4	25.0	25.0	25.0	25.1
Household income (%)					
	<1 million yen – 1.1	<$20,000 – 13.0	<£10,000 – 11.5	<€10,000 – 6.3	
	1 million yen level – 3.9	<$30,000 – 11.8	<£20,000 – 21.4	<€10,000 – 15.9	
	2 million yen level – 8.5	<$40,000 – 11.3	<£30,000 – 19.0	<€20,000 – 24.0	
	3 million yen level – 9.2	<$50,000 – 8.9	<£40,000 – 12.7	<€30,000 – 22.4	
	4 million yen level – 11.4	<$60,000 – 9.4	<£50,000 – 12.3	<€40,000 – 13.7	
	5 million yen level – 10.1	<$70,000 – 10.1	<£60,000 – 5.3	<€50,000 – 3.4	
	6 million yen level – 9.8	<$80,000 – 6.3	<£70,000 – 2.6	<€60,000 – 1.4	
	7 million yen level – 7.0	<$90,000 – 2.6	<£80,000 – 2.4	<€70,000 – 1.7	
	8 million yen level – 6.3	<$100,000 – 6.3	<£90,000 – 2.9	<€80,000 – 0.5	
	9 million yen level – 4.2	<$120,000 – 6.0	<£100,000 – 1.0	<€90,000 – 0.5	
	≥10 million yen – 12.7	<$160,000 – 6.0	<£120,000 – 0.7	≥€100,000 – 0.5	
	Not wish to answer – 15.8	<$200,000 – 1.4	<£160,000 – 0.2	Not wish to answer – 9.9	
		≥$200,000 – 1.4	<£200,000 – 0.2		
		Do not wish to answer – 5.5	≥£200,000 – 0.0		
			Do not wish to answer – 7.7		
Child or children (%)					
Yes	33.9	26.7	29.8	33.9	31.1
No	66.1	73.3	70.2	66.1	68.9

When asked if they usually mind the presence of GM products, 61% of respondents in Japan, 46% in the United States, 58% in the United Kingdom, and 72% in France answered that they minded seeing GM products in their daily grocery shopping. Multiple regression analyses showed significance for country (P<.001), gender (P<.001), age (P=.001), and education

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(*P*=.044). Females minded GM food significantly more than males with a *t* test (*P*=.001). Among countries, one-way ANOVA showed significance (*P*<.001). The Tukey test showed that respondents in France minded significantly more compared with those in the other 3 countries (*P*<.001). Gender and education did not show significance in the Tukey tests.

Fear of Health Hazards

Comparison of Demographics

Multiple linear regression analyses showed significant differences in gender (*P* ≤.001) except dioxin (*P*=.004); age (*P*<.001) except GM food (*P*=.004); and country (*P*<.001) except trans fatty acid (*P*=.012) and GM food (no significance). With *t* tests, females in Japan, the United States, and the United Kingdom felt fear significantly more than males, but there was no difference in France. The *P* values for each health hazard in each country are as follows: in Japan, norovirus (*P*=.042), radioactive materials (*P*=.012), BSE (*P*=.043), trans fatty acids (*P*=.047), acrylamide (*P*<.001), and methylmercury (*P*<.001); in the United States, norovirus (*P*=.048), radioactive materials (*P*=.012), trans fatty acid (*P*=.003), and GM food (*P*=.002); in the United Kingdom, food poisoning (*P*=.002), norovirus (*P*=.001), radioactive materials (*P*<.001), BSE (*P*<.001), trans fatty acids (*P*<.001), dioxin (*P*=.006), acrylamide (*P*<.001), methylmercury (*P*<.001), and GM food (*P*<.001).

With 1-way ANOVA, all questions regarding health hazards showed significance (*P*<.001) except trans fatty acid (*P*=.003). Accordingly, the post hoc tests (Tukey tests) for age groups showed that the 60s and older generation partially felt significantly stronger fear in several items than the 30s generation: in Japan, dioxin (*P*=.024), acrylamide (*P*=.008) and, methylmercury (*P*=.006); in the United States, BSE (*P*=.048) and methylmercury (*P*=.012); in the United Kingdom, norovirus (*P*=.030), dioxin (*P*<.001), acrylamide (*P*=.031), and methylmercury (*P*=.002).

Comparison of Countries

In a comparison among countries with ANOVA, significance was shown on each question regarding health hazards (*P*<.001). In a subsequent Tukey test, Japanese respondents felt significantly stronger fear than those in the other 3 countries for all causes of health hazards except GM food (*P*<.001). Respondents in Japan and France had significantly stronger fear of GM food than those in the United States and the United Kingdom (*P*<.001). There was no difference between Japan and France (Table 2). The effect size between Japan and each country on the other 3 countries for each health hazard is shown in Table 2.

Furthermore, the association between perception of GM food as a health hazard and perception of GM technology and food was examined. These factors are significantly associated for the United States and France. In both countries, respondents who think GM food poses a health hazard agreed with “1. Most consumers are not aware of risks to food safety” (US *P*=.021, odds=1.894, CI: 1.099-3.263; France *P*=.001, odds=3.133, CI: 1.657-5.923) and “2. Most consumers do not understand the risk of GM food” (US *P*=.006, odds ratio=2.500, CI: 1.280-4.885; France *P*<.001, odds ratio=3.677, CI: 1.817-7.442).

Respondents in Japan, the United Kingdom, and France who thought that GM food poses a health hazard significantly associated with “3. If provided with an explanation of GM technology, most consumers would accept GM food” (Japan *P*<.001, odds ratio=0.304, CI: 0.198-0.467; US *P*<.001, odds ratio=0.332, CI: 0.219-0.507; France *P*=.001, odds ratio=0.419, CI: 0.247-0.711).

Respondents in all participating countries who thought that GM food poses a health hazard significantly agreed with “4. Most consumers would accept GM food if provided with scientific data supporting its safety” (Japan *P*<.001, odds ratio=0.439, CI: 0.285-0.677; US *P*<.001, odds ratio=0.403, CI: 0.254-0.641; UK *P*<.001, odds ratio=0.356, CI: 0.227-0.554; France *P*<.001, odds ratio=0.361, CI: 0.202-0.646). Respondents in all participating countries who thought that GM food poses a health hazard significantly associated with “5. Most consumers would accept GM food if they understood that all food carries a certain level of risk” (Japan *P*=.001, odds ratio=0.488, CI: 0.325-0.733; US *P*=.007, odds ratio=0.568, CI: 0.376-0.858; UK *P*<.001, odds ratio= 0.358, CI: 0.235-0.543; France *P*=.001, odds ratio=0.440, CI: 0.274-0.708).

Japan showed significant association between perception that GM food poses a health hazard and “6. Most consumers cannot understand GM technology even if it is explained to them” (*P*<.001, odds ratio=2.408, CI: 1.614-3.594). Respondents in the United States significantly associated perception that GM food poses a health hazard and “7. Consumers should try hard to understand scientific information and learn more about the issue” (*P*=.009, odds ratio=2.200, CI: 1.226-3.948). France significantly associated perception that GM food poses a health hazard and “8. It is annoying to hear the same argument about safety of GM food repeated over and over, even when consumers do not understand it” (*P*=.006, odds ratio=1.919, CI: 1.218-3.022).

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Table 2. Fear of health hazards from food.[a,b]

Health hazard	Values	Japan	United States	the United Kingdom	France	ANOVA[c] (F value)	*P*
Food poisoning	Mean (SD[d])	4.98 (1.019)	4.10 (1.402)	4.09 (1.400)	4.09 (1.359)	51.691	<.001
	Effect size:g(CI)		0.73 (0.59 to 0.86)	0.73 (0.59 to 0.87)	0.74 (0.61 to 0.88)		
Norovirus	Mean (SD)	5.06 (0.981)	3.79 (1.482)	4.00 (1.446)	4.08 (1.434)	78.573	<.001
	Effect size:g(CI)		1.02 (0.88 to 1.16)	0.87 (0.73 to 1.01)	0.81 (0.67 to 0.94)		
Radioactive material	Mean (SD)	5.16 (1.047)	3.94 (1.658)	4.07 (1.612)	4.62 (1.481)	63.824	<.001
	Effect size:g(CI)		0.89 (0.75 to 1.03)	0.81 (0.67 to 0.95)	0.43 (0.29 to 0.56)		
BSE[e]	Mean (SD)	4.80 (1.154)	3.39 (1.370)	3.71 (1.513)	4.27 (1.515)	87.215	<.001
	Effect size:g(CI)		1.12 (0.97 to 1.26)	0.81 (0.68 to 0.95)	0.39 (0.26 to 0.53)		
Trans fatty acids	Mean (SD)	4.05 (1.120)	3.45 (1.368)	3.51 (1.289)	3.81 (1.290)	21.351	<.001
	Effect size:g(CI)		0.48 (0.35 to 0.62)	0.45 (0.31 to 0.58)	0.20 (0.07 to 0.33)		
Dioxin	Mean (SD)	4.95 (1.051)	3.62 (1.454)	3.56 (1.437)	4.40 (1.380)	108.179	<.001
	Effect size:g(CI)		1.05 (0.91 to 1.19)	1.12 (0.97 to 1.26)	0.45 (0.32 to 0.59)		
Acrylic amide in processed foods	Mean (SD)	4.36 (1.146)	3.52 (1.417)	3.47 (1.369)	4.04 (1.368)	45.431	<.001
	Effect size:g(CI)		0.66 (0.52 to 0.79)	0.71 (0.57 to 0.85)	0.25 (0.12 to 0.39)		
Methylmercury in fishery products	Mean (SD)	4.95 (1.059)	3.91 (1.450)	3.82 (1.397)	4.07 (1.422)	66.626	<.001
	Effect size:g(CI)		0.83 (0.69 to 0.96)	0.92 (0.78 to 1.06)	0.71 (0.57 to 0.84)		
GM[f] food	Mean (SD)	4.07 (1.196)	3.52 (1.490)	3.26 (1.429)	4.20 (1.427)	43.882	<.001
	Effect size:g(CI)		0.41 (0.27 to 0.54)	0.62 (0.48 to 0.75)	−0.10 (−0.23 to 0.03)		

[a]Likert Scale: 1=not afraid at all to 6=very afraid.

[b]Mean: average of Likert Scale points.

[c]ANOVA: analysis of variance.

[d]SD: standard deviation.

[e]BSE: bovine spongiform encephalopathy.

[f]GM: genetically modified.

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Resistance to Genetically Modified Products

Comparison of Demographics

Multiple linear regression analyses showed that gender was significantly associated with all GM products (*P*<.001), GM herbicide-tolerant crops (*P*=.035), and GM nutrient-enriched crops (*P*=.001), and country with 6 GM products: GM salmon, shining killifish, hay fever-alleviating rice, cold weather-tolerant crops, rapid-grow apples (*P*<.001, respectively), and GM drought-tolerant crops (*P*=.018). With t tests, females showed significantly stronger resistance to GM products in all 4 countries: in Japan, GM salmon (*P*<.001), GM shining killifish (*P*=.011), GM hay fever-alleviating rice (*P*=.009), GM herbicide-tolerant crops (*P*<.001), GM pest-resistant crops (*P*=.004), GM nutrient-enriched crops (*P*=.039), GM drought-tolerant crops (*P*=.006), GM cold weather-tolerant crops (*P*=.002), and GM rapid-grow apples (*P*<.001); in the United States, GM salmon (*P*<.001), GM shining killifish (*P*=.003), GM hay fever-alleviating rice (*P*=.001), GM herbicide-tolerant crops (*P*=.001), GM pest-resistant crops (*P*=.004), GM drought-tolerant crops (*P*=.011), GM cold weather-tolerant crops (*P*=.001), and GM rapid-grow apples (*P*<.001); in the United Kingdom, GM salmon (*P*<.001), GM shining killifish (*P*<.001), GM blue roses (*P*=.021), GM hay fever-alleviating rice (*P*<.001), GM herbicide-tolerant crops (*P*<.001), GM pest-resistant crops (*P*<.001), GM nutrient-enriched crops (*P*=.018), GM drought-tolerant crops (*P*<.001), GM cold weather-tolerant crops (*P*<.001), and GM rapid-grow apples (*P*<.001); and in France, GM hay fever-alleviating rice (*P*=.010), GM pest-resistant crops (*P*=.034), and GM cold weather-tolerant crops (*P*=.020).

Comparison of Countries

The comparison among countries showed significance in every GM product with 1-way ANOVA (*P*<.001). With Tukey tests, France showed significantly stronger resistance than the other 3 countries for 5 items: GM salmon, GM shining killifish, GM hay fever-alleviating rice, GM cold weather-tolerant crops, and GM rapid-grow apples (*P*<.001, respectively). For GM herbicide-tolerant crops, GM pest-resistant crops, and GM nutrient-enriched crops, respondents in both France and Japan showed significantly stronger resistance than those in the United States and the United Kingdom (Figure 1), with no significant difference between France and Japan (*P*<.001 in Japan and *P*<.001 in France). Japanese respondents expressed significantly stronger resistance compared with those in the United Kingdom for GM drought-tolerant crops (*P*<.001) and GM cold weather-tolerant crops (*P*<.001, g=−.25, CI: −0.378 to −0.112). In addition, Japanese respondents expressed significantly stronger resistance compared to those in the United States (*P*<.001, g=−0.32, CI: −0.448 to −0.181) and the United Kingdom (*P*<.001, g=−0.41, CI: −0.542 to −0.274) for GM rapid-grow apples (Table 3, Figure 2).

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Table 3. Resistance to GM[a] versus breeding-improved products.[b,c]

Item	Values	Japan	United States	the United Kingdom	France	ANOVA[d] (F value)	*P*
GM products							
Salmon that grows twice as fast as traditional salmon							
	Mean (SD[e])	2.60 (1.186)	2.77 (1.495)	2.80 (1.453)	2.07 (1.173)	26.618	<.001
	Effect size:g(CI)		−0.12 (−0.26 to 0.01)	−0.15 (−0.29 to −0.02)	0.45 (0.31 to 0.58)		
Killifish whose bodies shine like tropical fish							
	Mean (SD)	2.76 (1.279)	2.81 (1.490)	2.80 (1.481)	2.25 (1.282)	16.090	<.001
	Effect size:g(CI)		−0.04 (−0.17 to 0.10)	−0.03 (−0.16 to 0.10)	0.40 (0.26 to 0.53)		
Rose with blue-colored blossoms							
	Mean (SD)	3.60 (1.339)	4.03 (1.567)	3.80 (1.555)	3.46 (1.655)	10.982	<.001
	Effect size:g(CI)		−0.29 (−0.43 to −0.16)	−0.13 (−0.27 to 0.00)	0.10 (−0.03 to 0.23)		
Rice that relieves symptoms of hay fever when continuously consumed							
	Mean (SD)	3.29 (1.250)	3.47 (1.529)	3.50 (1.529)	2.70 (1.358)	28.565	<.001
	Effect size:g(CI)		−0.13 (−0.26 to 0.01)	−0.15 (−0.28 to −0.01)	0.46 (0.32 to -0.59)		
Crops resistant to certain herbicides or weed killers							
	Mean (SD)	2.521.223	3.31 (1.500)	3.53 (1.459)	2.36 (1.263)	75.926	<.001
	Effect size:g(CI)		−0.58 (−0.71 to −0.44)	−0.76 (−0.89 to −0.62)	0.13 (0.00 to 0.26)		
Crops resistant to specific harmful pests							
	Mean (SD)	2.68 (1.233)	3.41 (1.515)	3.63 (1.483)	2.64 (1.319)	55.933	<.001
	Effect size:g(CI)		−0.53 (−0.66 to −0.39)	−0.70 (−0.84 to −0.56)	0.03 (−0.10 to 0.16)		
Crops enriched with specific nutrients such as vitamin C, etc.							
	Mean (SD)	3.18 (1.178)	3.81 (1.486)	3.74 (1.456)	2.98 (1.349)	38.545	<.001
	Effect size:g(CI)		−0.48 (−0.61 to −0.34)	−0.43 (−0.56 to −0.29)	0.16 (0.03 to 0.29)		
Crops that make efficient use of water and grow in arid or drought-stricken environments							
	Mean (SD)	3.52 (1.194)	3.77 (1.489)	3.92 (1.464)	3.68 (1.622)	5.879	<.001
	Effect size:g(CI)		−0.19 (−0.32 to −0.05)	−0.30 (−0.44 to −0.17)	−0.12 (−0.25 to 0.02)		
Crops resistant to cold weather and extremely low temperatures							
	Mean (SD)	3.54 (1.228)	3.76 (1.486)	3.87 (1.391)	3.00 (1.392)	33.284	<.001
	Effect size:g(CI)		−0.16 (−0.29 to −0.03)	−0.25 (−0.38 to −0.11)	0.42 (0.29 to 0.55)		
Apples that ripen faster and can be picked sooner than regular apples							
	Mean (SD)	2.99 (1.227)	3.41 (1.467)	3.54 (1.464)	2.59 (1.314)	41.780	<.001
	Effect size:g(CI)		−0.32 (−0.45 to −0.18)	−0.41 (−0.54 to −0.27)	0.32 (0.18 to 0.45)		
Breeding-improved products							
Salmon that grows twice as fast as traditional salmon							
	Mean (SD)	3.16 (1.303)	3.47 (1.617)	3.41 (1.553)	2.44 (1.392)	42.752	<.001

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Item	Values	Japan	United States	the United Kingdom	France	ANOVA[d] (F value)	*P*
	Effect size:g(CI)		−0.21 (−0.35 to −0.08)	−0.18 (−0.31 to −0.04)	0.53 (0.39 to 0.66)		
Killifish whose bodies shine like tropical fish							
	Mean (SD)	3.26 (1.362)	3.33 (1.610)	3.29 (1.559)	2.52 (1.419)	28.371	<.001
	Effect size:g(CI)		−0.05 (−0.18 to 0.08)	−0.02 (−0.16 to 0.11)	0.53(0.39 to 0.66)		
Rose with blue-colored blossoms							
	Mean (SD)	3.90 (1.353)	4.28 (1.481)	4.07 (1.526)	3.56 (1.699	16.749	<.001
	Effect size:g(CI)		−0.27 (−0.41 to −0.14)	−0.12 (−0.25 to 0.01)	0.22 (0.08 to 0.35)		
Rice that relieves symptoms of hay fever when continuously consumed							
	Mean (SD)	3.67 (1.285)	3.94 (1.472)	3.96 (1.475)	2.95 (1.483)	44.944	<.001
	Effect size:g(CI)		−0.20 (−0.33 to −0.06)	−0.21 (−0.34 to −0.08)	0.52 (0.38 to 0.65)		
Crops resistant to certain herbicides or weed killers							
	Mean (SD)	3.23 (1.329)	3.89 (1.492)	4.07 (1.435)	2.76 (1.451)	75.119	<.001
	Effect size:g(CI)		−0.47 (−0.60 to −0.33)	−0.61 (−0.74 to −0.47)	0.34 (0.21 to 0.47)		
Crops resistant to specific harmful pests							
	Mean (SD)	3.30 (1.347)	4.01 (1.494)	4.13 (1.442)	2.91 (1.497)	68.251	<.001
	Effect size:g(CI)		−0.51 (−0.64 to −0.37)	−0.60 (−0.73 to −0.46)	0.27 (0.14 to 0.41)		
Crops enriched with specific nutrients such as vitamin C, etc.							
	Mean (SD)	3.62 (1.247)	4.17 (1.434)	4.14 (1.391)	3.15 (1.515)	49.784	<.001
	Effect size:g(CI)		−0.41 (−0.54 to −0.28)	−0.39 (−0.52 to −0.26)	0.34 (0.21 to 0.47)		
Crops that make efficient use of water and grow in arid or drought-stricken environments							
	Mean (SD)	3.91 (1.265)	4.26 (1.368)	4.23 (1.393)	3.62 (1.650)	18.882	<.001
	Effect size:g(CI)		−0.27 (−0.40 to −0.14)	−0.24 (−0.37 to −0.11)	0.20 (0.06 to 0.33)		
Crops resistant to cold weather and extremely low temperatures							
	Mean (SD)	3.87 (1.265)	4.18 (1.405)	4.22 (1.405)	3.16 (1.513)	51.176	<.001
	Effect size:g(CI)		−0.23 (−0.37 to −0.10)	−0.26 (−0.39 to −0.13)	0.51 (0.38 to 0.65)		
Apples that ripen faster and can be picked sooner than regular apples							
	Mean (SD)	3.49 (1.277)	4.00 (1.473)	4.00 (1.464)	2.90 (1.441)	56.599	<.001
	Effect size:g(CI)		−0.37 (−0.50 to −0.24)	−0.38 (−0.51 to −0.24)	0.43 (0.29 to 0.56)		

[a]GM: genetically modified.

[b]Likert Scale: 1= very strong resistance to 6= no resistance at all.

[c]Mean: average of Likert Scale points.

[d]ANOVA: analysis of variance.

[e]SD: standard deviation.

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Figure 1. Change in consumer resistance to GM and breeding-improved food. GM: genetically modified.

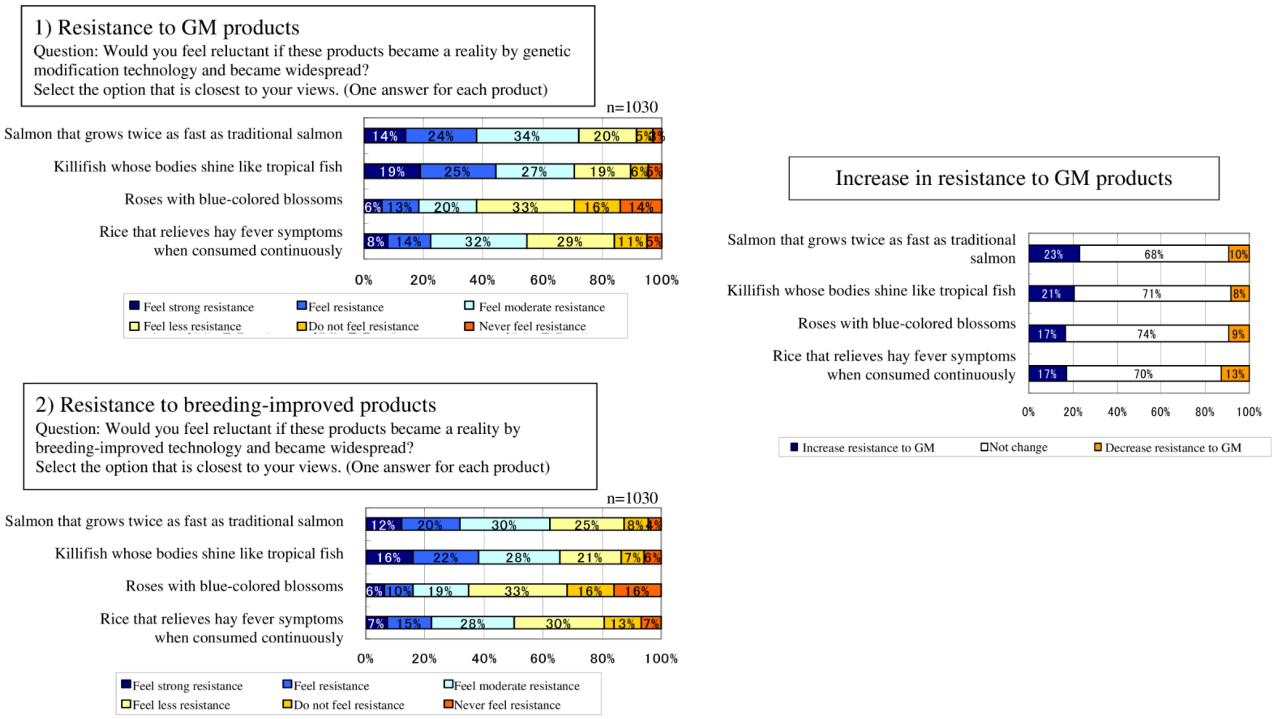
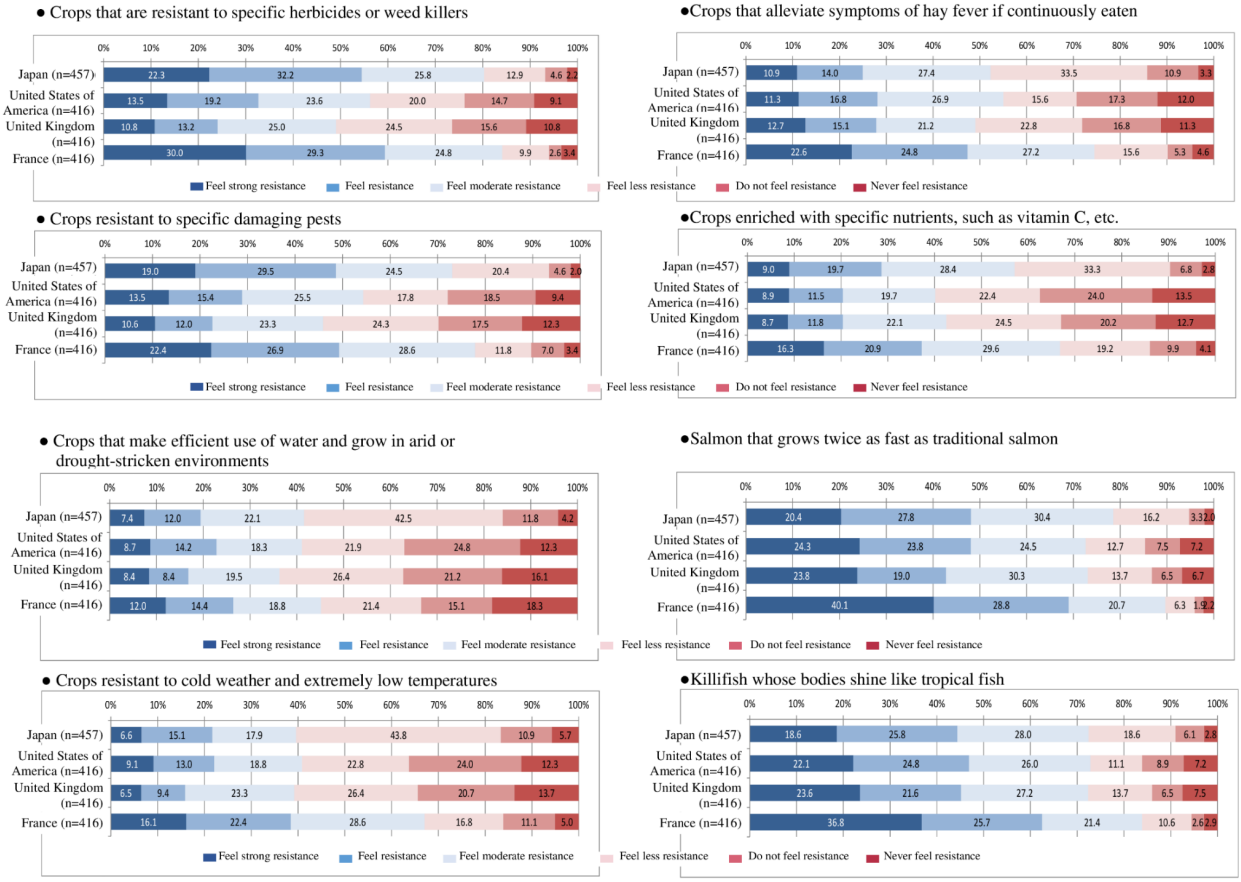


Figure 2. Resistance to GM products. (Respondents were asked to answer only for products available in their country.).



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Resistance to Breeding-Improved Products

Comparison of Demographics

Multiple regression analyses showed significant differences in all questions for gender (P<.001); country (P<.001) except for breeding-improved pest-resistant crops (P=.007) and drought-tolerant crops (P=.005); and education for breeding-improved salmon (P=.014), shining killifish (P=.023), crops that relieve symptoms of hay fever when continuously consumed (P<.001), crops resistant to certain herbicides or weed killers (P=.003), crops resistant to specific harmful pests (P=.003), crops enriched with specific nutrients (P<.001), crops that make efficient use of water and grow in arid or drought-stricken environments (P<.001), crops resistant to cold weather and extremely low temperatures (P=.001), and apples that ripen faster and can be picked sooner than regular apples (P=.003) (Table 3).

With *t* tests, females felt stronger resistance for all breeding-improved products in the United Kingdom, and all except a couple of items in Japan and the United States, and some items in France: breeding-improved salmon (P<.001 in the United Kingdom, Japan, and the United States); breeding-improved shining killifish (P<.001 in the United Kingdom, P=.030 in Japan, and P=.010 in the United States); breeding-improved blue roses (P=.012 in the United Kingdom); breeding-improved hay fever-alleviating rice (P=.002 in the United Kingdom, P=.001 in Japan, P=.001 in the United States, and P<.001 in France); breeding-improved herbicide-tolerant crops (P=.004 in the United Kingdom, P<.001 in Japan, P=.015 in the United States, and P=.046 in France); breeding-improved pest-resistant crops (P=.008 in the United Kingdom, P<.001 in Japan, P=.007 in the United States, and P=.014 in France); breeding-improved nutrient-enriched crops (P=.044 in the United Kingdom, and P=.002 in Japan); breeding-improved drought-tolerant crops (P=.010 in the United Kingdom, P=.001 in Japan, and P=.022 in the United States); breeding-improved cold weather-tolerant crops (P=.009 in the United Kingdom, P<.001 in Japan, P=.005 in the United States, and P=.035 in France); and breeding-improved rapid-grow apples (P<.001 in the United Kingdom, Japan, and the United States; and P=.021 in France).

Respondents without higher education showed significantly stronger resistance in all items in the United States, in all except one item in the United Kingdom, in some items in Japan, and one item in France: breeding-improved salmon (P=.030 in the United Kingdom, and P=.005 in the United States); breeding-improved shining killifish (P=.007 in the United Kingdom, P=.026 in the United States, and P=.039 in France); breeding-improved blue roses (P=.007 in the United Kingdom, and P=.017 in the United States); breeding-improved hay fever-alleviating rice (P=.005 in the United Kingdom, P=.031 in Japan, and P=.002 in the United States); breeding-improved herbicide-tolerant crops (P=.001 in the United Kingdom, and P=.024 in the United States); breeding-improved pest-resistant crops (P=.003 in the United Kingdom, and P=.002 in the United States); breeding-improved nutrient-enriched crops (P=.013 in Japan, and P<.001 in the United States); breeding-improved drought-tolerant crops (P=.030 in the United Kingdom, P=.015 in Japan, and P<.001 in the United States); breeding-improved cold weather-tolerant crops (P=.002 in the United Kingdom, P=.018 in Japan, and P<.001 in the United States); and breeding-improved rapid-grow apples (P<.001 in the United Kingdom, P=.020 in Japan, and P=.002 in the United States).

Comparison of Countries

Overall, resistance to breeding-improved products is about 20% weaker than to GM products (Figure 1). Comparisons among countries revealed significant differences. For all breeding-improved items, France showed significantly stronger resistance than the other 3 countries (P<.001). Japan showed stronger resistance to breeding-improved salmon (P=.009, g=−0.21, CI: −0.347 to −0.081) than the United States. Japan also showed stronger resistance to 7 breeding-improved products than the United States and the United Kingdom: breeding-improved hay fever-alleviating rice (P=.025, g=−0.20, CI: −0.331 to −0.064 for the United States, and P=.015, g=−0.21, CI: −0.343 to −0.076 for the United Kingdom), herbicide-tolerant crops (P<.001, g=−0.47, CI: −0.603 to −0.333 for the United States, and P<.001, g=−0.61, CI: −0.740 to −0.469 for the United Kingdom), pest-resistant crops (P<.001 for both the United States and the United Kingdom), nutrient-enriched crops (P<.001 for both the United States and the United Kingdom), drought-tolerant crops (P=.001, −0.27, CI: −0.404 to −0.137 for the United States, and P=.005, g=−0.24, CI: −0.374 to −0.108 for the United Kingdom), cold weather-tolerant crops (P=.006, g=−0.23, CI: −0.365 to −0.099 for the United States and P=.001, g=−0.26, CI: −0.394 to −0.127 for the United Kingdom), and rapid-grow apples (P<.001, g=−0.37, CI: −0.504 to −0.236 for the United States, and P<.001, g=−0.38, CI: −0.509 to −0.241 for the United Kingdom, Table 3).

Perception of Genetically Modified Technology and Food

Comparison of Demographics

Country showed significant differences for all items, and age in some products in the multiple linear regression analyses. For country: “1. Most consumers are not aware of risks to food safety” (P<.001), “2. Most consumers do not understand the risk of GM food” (P=.010), “3. If provided with an explanation of genetically modified technology, most consumers would accept GM food” and “4. Most consumers would accept GM food if provided with scientific data supporting its safety” (P<.001), “5. Most consumers would accept GM food if they understood that all food carries a certain level of risk” (P=.006), “6. Most consumers cannot understand genetically modified technology even if it is explained to them” (P<.001), “7. Consumers should try hard to understand scientific information and learn more about the issue” (P=.009), and “8. It is annoying to hear the same argument about safety of GM food repeated over and over, even when consumers don’t understand it” (P=.023). For age: “6. Most consumers cannot understand genetically modified technology even if it is explained to them” (P<.001), “7. Consumers should try hard to understand scientific information and learn more about the issue” (P=.003), and “8. It is annoying to hear the same argument about safety of GM food repeated over and over, even when consumers don’t

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understand it" (*P*=.031). With 1-way ANOVA, Japan did not show any significance for age, but other countries showed significant differences. With the Tukey tests, for "1. Most consumers are not aware of risks to food safety," only France showed a significant difference between respondents in their 40s and those in their 50s (*P*=.018). For "2. Most consumers do not understand the risk of GM food," the United Kingdom showed respondents in their 50s significantly agreed compared to those in their 30s (*P*=.012), and France showed respondents in their 50s significantly agreed compared to those in their 60s (*P*=.012).

For "3. If provided with an explanation of genetically modified technology, most consumers would accept GM food," only respondents in their 60s in the United Kingdom significantly strongly disagreed compared to those in their 50s (*P*<.001). For "4. Most consumers would accept GM food if provided with scientific data supporting its safety," only UK respondents in their 60s significantly strongly disagreed compared to those in their 50s (*P*=.007). For "5. Most consumers would accept GM food if they understood that all food carries a certain level of risk," only the United Kingdom showed significance for respondents in their 60s compared to those in their 30s (*P*=.036) and 50s (*P*<.001). For "6. Most consumers cannot understand genetically modified technology even if it is explained to them," only USA respondents in their 60s significantly strongly agreed compared to those in their 30s (*P*=.043). For "7. Consumers should try hard to understand scientific information and learn more about the issue," respondents in their 30s significantly strongly disagreed compared to those in their 50s (*P*=.033 in the United Kingdom and *P*=.42 in France). For "8. It is annoying to hear the same argument about safety of GM food repeated over and over, even when consumers don't understand it," only France showed significant strongly agree for respondents in their 30s compared to those in their 40s (*P*=.013), and between those in their 40s and 50s (*P*=.003).

Comparison of Countries

A comparison among countries showed significance for each item (*P*<.001). Tukey tests showed that most respondents in the 3 participating countries other than Japan were not as aware of food safety, whereas Japanese respondents were significantly strongly aware of food safety (*P*<.001, g=0.50, CI: 0.367-0.637 for the United States; *P*=.003, g=0.23, CI: 0.095-0.361 for the United Kingdom; and *P*<.001, g=0.84, CI: 0.701-0.979 for France). Furthermore, around 90% of respondents in each country agreed that "2. Most consumers do not understand the risk of GM food," and respondents in France agreed with the statement more than those in Japan (*P*=.017, g=0.23, CI: 0.093-0.359) and the United Kindom (*P*=.017, g=−0.19, CI: −0.330 to −0.057; Table 4).

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Table 4. Recognition of risk from GM[a] technology and food.[b-d]

Item	Values	Japan	United States	the United Kingdom	France	ANOVA[e] (F value)	*P*
1. Most consumers are not aware of risks to food safety.							
	Mean (SD[f])	2.96 (1.066)	2.39 (1.184)	2.69 (1.287)	2.07 (1.047)	48.112	<.001
	Effect size:g (CI)		0.50 (0.37 to 0.64)	0.23 (0.09 to 0.36)	0.84 (0.70 to 0.98)		
2. Most consumers do not understand the risk of GM food.							
	Mean (SD)	2.27 (0.862)	2.18 (1.141)	2.28 (1.224)	2.06 (1.024)	3.902	.009
	Effect size:g (CI)		0.09 (−0.04 to 0.22)	−0.01 (−0.14 to 0.13)	0.23 (0.09 to 0.36)		
3. If provided with an explanation of genetically modified technology, most consumers would accept GM food.							
	Mean (SD)	3.39 (1.081)	3.12 (1.225)	3.19 (1.234)	2.93 (1.321)	10.709	<.001
	Effect size:g (CI)		0.23 (0.10 to 0.36)	0.17 (0.04 to 0.30)	0.38 (0.25 to 0.52)		
4. Most consumers would accept GM food if provided with scientific data supporting its safety.							
	Mean (SD)	3.26 (1.073)	2.93 (1.236)	3.03 (1.188)	2.82 (1.288)	10.546	<.001
	Effect size:g (CI)		0.28 (0.15 to 0.42)	0.20 (0.07 to 0.33)	0.37 (0.23 to 0.50)		
5. Most consumers would accept GM food if they understood that all food carries a certain level of risk.							
	Mean (SD)	3.42 (1.059)	3.16 (1.258)	3.22 (1.199)	3.16 (1.415)	4.443	.004
	Effect size:g (CI)		0.22 (0.09 to 0.35)	0.18 (0.05 to 0.31)	0.21 (0.08 to 0.35)		
6. Most consumers cannot understand genetically modified technology even if it is explained to them.							
	Mean (SD)	3.18 (1.027)	2.97 (1.299)	2.98 (1.226)	2.80 (1.304)	6.948	<.001
	Effect size:g (CI)		0.17 (0.04 to 0.31)	0.18 (0.05 to 0.31)	0.32 (0.19 to 0.45)		
7. Consumers should try hard to understand scientific information and learn more about the issue.							
	Mean (SD)	2.68 (0.898)	2.45 (1.159)	2.66 (1.125)	2.86 (1.370)	8.659	<.001
	Effect size:g (CI)		0.22 (0.08 to 0.35)	0.02 (−0.12 to 0.15)	−0.16(−0.29 to −0.03)		
8. It is annoying to hear the same argument about safety of GM food repeated over and over, even when consumers don't understand it.							
	Mean (SD)	3.12 (1.047)	3.22 (1.326)	3.34 (1.198)	2.87 (1.409)	11.050	<.001
	Effect size:g (CI)		−0.08 (−0.22 to 0.05)	−0.20 (−0.33 to −0.06)	0.21 (0.08 to 0.34)		

[a]GM: genetically modified.

[b]"Consumers" in this paper means nonexperts.

[c]Likert Scale: 1= strongly agree → 6= strongly disagree.

[d]Mean: average of Likert Scale points.

[e]ANOVA: analysis of variance.

[f]SD: standard deviation.

France significantly agreed that most consumers would accept GM food "if provided with an explanation of GM technology," "if provided with scientific data supporting its safety," and "if most consumers understand that any food carries a level of risk." However, Japanese respondents showed significant disagreement with these statements: "3. If provided with an explanation of genetically modified technology, most consumers would accept GM food" for the United States (*P*=.007, g=0.23, CI: 0.096-0.363) and for France (*P*<.001, g=0.38, CI: 0.250-0.518); "4. Most consumers would accept GM food if provided with scientific data supporting its safety" for the United States (*P*<.001, g=0.28, CI: 0.151-0.418), the United Kingdom (*P*=.026, g=0.20, CI: 0.068-0.334), and France (*P*<.001, g=0.37, CI: 0.233-0.501); and "6. Most consumers would accept GM food if they understood that all food carries a certain level of risk" for the United States (*P*=.012, g=0.22, CI: 0.088-0.355) and France (*P*=.009, g=0.21, CI: 0.079-0.346). Furthermore, 58% of respondents in Japan agreed that "6. Most consumers cannot understand GM technology, even if it is explained to them," whereas about 70% of respondents in the other 3 countries showed agreement; significantly fewer respondents in Japan think that GM technology is understandable than in France (*P*<.001, g=0.32, CI: 0.187-0.454; Table 4).

For the statement "7. Most consumers should try hard to understand scientific information and learn more about the issue," a significant difference was observed among countries; USA respondents showed significance in agreement compared with those in Japan (*P*=.022, g=0.22, CI: 0.082-0.348) and France (*P*<.001, g=−0.16, CI: −0.292 to −0.025; Table 4). For

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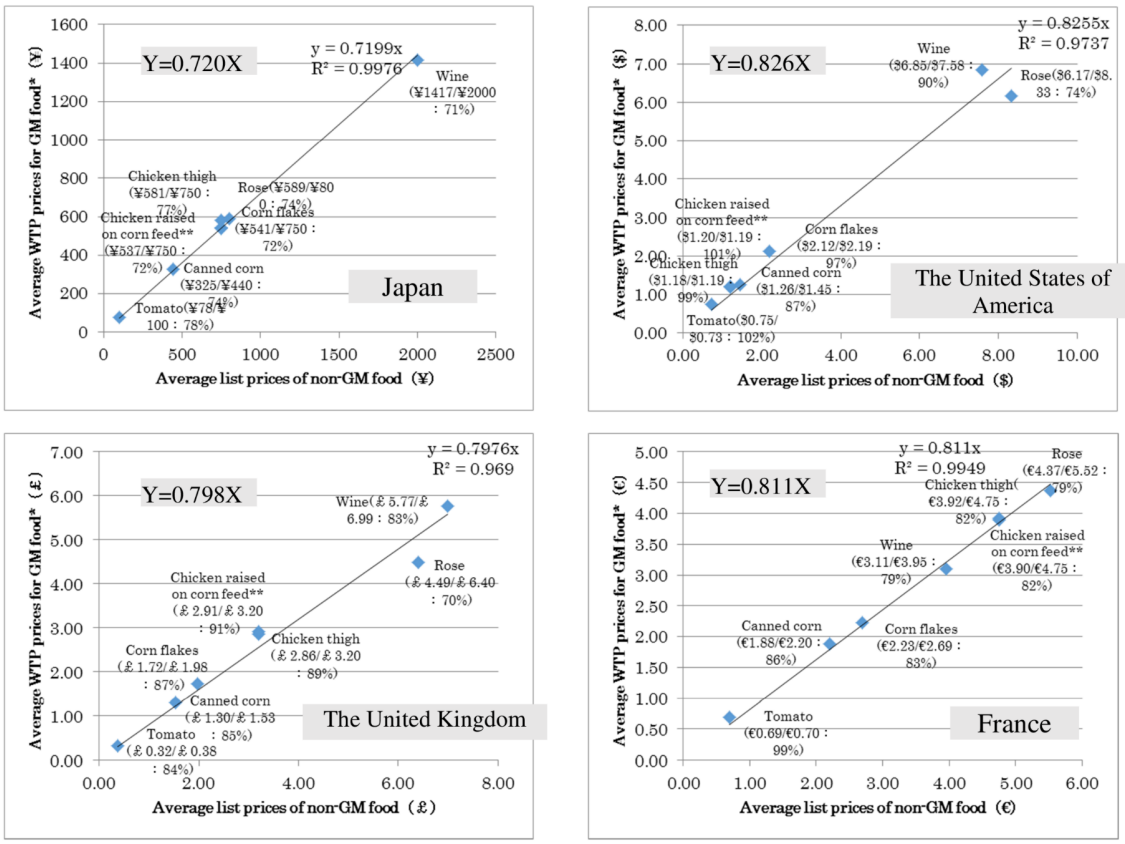
the statement, "8. It is annoying to hear the same argument about safety of GM food repeated over and over, even when consumers don't understand it," the respondents who agreed were 67%, 70%, 61%, and 59% in Japan, France, the United States, and the United Kingdom, respectively. With a Tukey test, a significant difference among the countries was shown; French respondents agreed significantly more with this statement than respondents in Japan (P=.012, g=0.21, CI: 0.077-0.343), the United States (P<.001, g=−0.262, CI: −0.398 to −0.125), and the United Kingdom (P<.001, g=−0.366, CI: −0.502 to −0.228; Table 4).

Willingness to Pay to Measure Resistance to Genetically Modified Food

Participants who answered that they intended to purchase GM products were asked to indicate their WTP for GM food. Japanese consumers were willing to accept about a 30% discount for GM food compared to the average market-list price for comparable non-GM food, whereas respondents in the other 3 countries would accept a discount of approximately 20% for GM food (Figure 3).

Figure 3. Comparison of WTP for GM and non-GM food. GM: genetically modified, WTP: willingness to pay.



*WTP prices on y axis if each would be GM food. **Chicken is not GM but is fed GM corn on y axis.

Discussion

Principal Findings

This study attempted to illustrate Japanese perceptions of GM food in comparison with 3 other countries.

More than expected in H1, demographic factors of gender, age, and education overall seem to somewhat influence consumers' perceptions; females, people in their 50s and older, and those with less education tended to show strong resistance to GM food in this study. These results confirmed previous studies that some demographic items were related to consumer perceptions [14,35]. However, France was not entirely in line with these results. Empirically, people who have a child or children may be more sensitive to perceived risks so we could surmise that they may exhibit resistance to GM food. Contrary to this empirical speculation, however, people with children did not show significant resistance to GM food in this study. In this and previous studies, each nation's experiences and social factors contribute to the evolution of consumer perceptions [8-13,29,30,35,36]. This study showed that these demographic factors are still influencing, but not determinants of, consumer perceptions.

Even though GM food has no documented health risks thus far, affect/emotional reactions to perceived risk appear to be stronger than cognitive understanding [35]. In this case, although educational approaches that present information consumers need to know—as opposed to what they want to know—have not been shown to promote perception and attitude change, ongoing education that specifically addresses consumers' concerns may reduce their fear and help them understand GM technology [3,14,29,37]. Effective educational materials should be examined in future research.

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One aim of this research was to determine how fear of health hazards may disturb the intent to understand and accept GM food as shown in H2. Previous studies discussed that consumers often recognize that food purchased from the market is largely safe to eat [38], and food choices frequently reflect compromises in consumers' life style rather than their preferences [29]. In this study, however, consumers in all participating countries showed a degree of fear of health hazards from food contamination. Especially, Japanese respondents expressed the strongest fear and/or sensitivity to health hazards from food compared to those in other countries (Table 2). Consumers in Japan and France seemed to recognize GM food as something that poses a health risk, and showed stronger resistance than the United States and the United Kingdom.

Based on the results of the association between the perception that GM food poses a health hazard and the perceptions related to GM technology and food, even consumers who believe that GM food poses a health hazard desire scientific data to support its safety; they appear not to have enough data to confirm GM food safety. Therefore, US consumers are aware that they also need to study scientific information about products they consume. Contrary to the United States, however, consumers in France who thought GM food poses a health hazard expressed annoyance at repeatedly having to hear the same argument about the safety of GM food. The countries with high levels of uncertainty avoidance, such as Japan and France, may be influenced in their resistance to GM food and seek solid answers about GM food [25,26]. Under these circumstances, having more information may not lead to a solution that resolves the uncertainty presented by GM food; consumers in France may become irritated by explanations of GM food and still remain uncertain.

When the term "GM" was replaced with the term "breeding improved" for the same products, as stated in H3, consumer resistance was reduced (Table 3). The results of this study suggest that "GM" may already have a negative connotation in consumers' minds, especially in Japan and France, which have the strongest resistance to GM food. In addition, it was considered that people may not have enough information about GM food to construct their attitudes and may be more influenced emotionally by perceived risk. This is in line with previous reports showing that affect influences perceived risk [8,35].

Although this study did not formulate a hypothesis for consumers' acceptance of specific GM food items, we additionally found that all 4 countries showed some resistance to GM products, but there was variance among them. GM organisms, such as GM salmon, evoked stronger resistance than GM crops in this study, a finding that was also reported by previous studies [3,15,29]. GM products with advantages primarily for product producers, such as GM herbicide-tolerant and pest-resistant crops, also showed strong resistance. However, GM products that have direct advantages for consumers and/or have advantages under certain daily and/or environmental conditions appeared to evoke relatively less resistance.

For instance, hay fever is such a common seasonal symptom in Japan that it is called "the national disease" due to the large number of people who suffer from it. Another example from France is the severe drought in 2003 that led to extreme aridity and the water restrictions that were put in place in 2011; among French consumers, resistance to drought-tolerant GM food was relatively weaker in our study, although a link to consumers' experiences of the environmental and social events of 2003 and 2011 was not examined in this study (Figure 3). Previous studies have argued that a mix of factors, including social and psychological, and the risks and benefits of each food, may influence risk perceptions [9-13,29,30], affect [35], moral convictions, fairness [8], and attitudes regarding the benefits and risks of GM food [36]. Although a direct relationship between the level of resistance and specific natural and industrial disasters, as well as food-related incidents such as food poisoning, were not investigated in this study, we can still speculate that the circumstance and experiences of each country can affect the level of resistance to GM food.

Although Hoban (1997) [2] and Hoban (1999) [15] found that consumers in Japan and the United States have shown relatively weak reactions to GM food and seem to have no great concern and/or objection to GM food becoming commercially available, the results of this study indicated otherwise, confirming H4. The results from WTP also support this finding. Japanese respondents who do not mind purchasing GM food showed the strongest resistance to GM food in the WTP questions compared to the other countries. Contrary to findings in a previous study that only USA consumers would accept GM food if they could purchase it at a discounted price [39], this study found that consumers in the United States, France, and the United Kingdom who did not mind purchasing GM food showed the same level of discounted price in the WTP questions. The stronger resistance shown by consumers willing to purchase GM food in Japan compared to the United States, France, and the United Kingdom indicates that there may be much stronger unexpressed resistance among Japanese consumers who are not willing to purchase GM food.

Understanding the personal benefits of GM food, and the ability to purchase it at more than 30% off the list price for comparable non-GM food may be effective communication cues for Japanese consumers, as would be about a 20% discount for consumers in the other participating countries. Although the impact of such communication on consumers may be short lived, it can be used to start discussions about GM food and its safety among consumers. In this regard, it should be stated that Japanese nonverbal reactions are sometimes stronger than superficially expressed; people tend to be reluctant to freely express individual opinions or attitudes because they value social balance and prefer to accommodate to the situational context [27,28]. To account for this cultural difference, it is important that future research on Japanese consumer perceptions develop a tool to detect and measure discrepancies that may exist between a person's verbalized response and their emotional reaction.

Contrary to Japanese consumers' negative perceptions of GM food, they appeared to accept GM technology slightly more than those in the other countries, which was not in line with H5, while still rejecting its application to GM food. Japanese and French consumers may be unlikely to accept GM food even if

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shown scientific evidence of its safety, provided with understandable explanations of GM food, and helped to understand that consuming any food carries a risk, even though they seem to desire safety. This lack of information may have several effects: it may increase their uncertainty [21]; it may strengthen the belief that GM food causes health hazards to create certainty [9]; or it may tighten their hold on preexisting attitudes [23]. Furthermore, Japanese and French consumers' high level of uncertainty avoidance may also influence their perception not to accept GM food [26]. Under these circumstances, continuously providing scientific and other necessary information may, in fact, lead to greater feelings of distrust and may disturb Japanese consumers' proactive thinking about GM food [6,7].

Although Japanese consumers showed slightly less resistance toward GM technology, there is a gap between welcoming the advanced technology and accepting its use in food production. As Siegrist [35] stated, perception of GM technology seemed to depend on its application. It is still unclear whether perception and acceptance of GM technology by Japanese consumers depends on the type of GM technology application. The mechanisms between their perceptions of GM food and their experiences should be examined in a future study.

Conclusion

As the results of this study show, every participating country showed a degree of resistance to GM food; however, France and Japan had overall stronger resistance than the United States and the United Kingdom. It appeared that each country's experiences may be related to its consumers' acceptance of GM food. In fact, the term, "GM food" itself seemed to already carry a negative connotation. The belief that GM food poses health hazards is likely to be associated with the perception of GM food, which, in turn, appears to be related to their cultural predispositions toward uncertainty avoidance. Consumers in each country would like the assurance of scientific data proving that GM food is safe, but as long as such assurance is not provided consumers in each country may rely on less information to create their perceptions and attitudes, be less likely to seek out more information regarding GM food, and may not accept GM food.

To motivate and influence processing of information about GM food, it may be more effective to use the ELM peripheral route, employing communication cues that emphasize benefits to consumers, including setting discount prices, constantly providing information to overcome each country's experiences as well as ensure the safety of GM food. Basically, cultural differences among the participating countries did not appear to strongly influence acceptance or nonacceptance of GM food. Therefore, some measurements developed in Western cultures would be adaptable to the Japanese context. However, we must keep in mind that Japanese cultural traits that place a high importance on social balance and harmony may demotivate consumers to express their true opinion. This cultural predisposition should be carefully considered and measured in future studies.

Limitations

A limitation of our study design is that it excluded people who are not familiar with the Internet and do not use a computer. However, taking into consideration rising rates of computer and Internet use, the increasing acceptance of Web-based academic studies, and the quality control implemented by Macromill and Tokyo to prevent invalid responses, our model for conducting Web-based studies remains an effective way to collect international data.

Furthermore, the recruitment rate for the Web-based survey employed in this study was low, which may bias the results. We were only able to communicate with our international respondents via email to remind them to complete the questionnaire. Even with this limitation, however, we were able to obtain at least 400 completed questionnaires from each of the 4 countries surveyed, a number sufficient for meaningful statistical analyses and to yield important information about Japanese consumer characteristics and how they compare to those of the other 3 nations.

We chose 3 countries to compare: the United States, the United Kingdom, and France. Selecting these countries might bias this research. However, comparison with these countries provided new perspectives and insights about GM food for Japanese consumers and those in the other nations selected. In the future, we would like to conduct studies comparing Japanese perceptions with other countries than those in this study.

This study focused on health hazards as a reason for resistance, which is one of the main trends of discussion regarding GM food risks. Mechanisms to reduce this fear were not examined in this study. Further studies should be conducted to evaluate the reaction mechanisms of Japanese consumers to other risk-relevant concepts, such as environmental conditions, consumers' rights, source characteristics, and the benefits of GM food. However, it remains meaningful to observe the unique characteristics of Japanese consumer perceptions toward risk and to provide new perspectives for the participating countries.

In hindsight, several questions in the survey were double-barreled. Although the aim of this study was not affected, we need to revise these questions in future studies. As for the cultural influences alluded to in this study, we need to conduct future studies that focus solely on such cultural differences.

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Conflicts of Interest

None declared.

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Abbreviations

CFA: confirmatory factor analysis
EFA: exploratory factor analysis
ELM: elaboration likelihood model
GM: genetically modified
WTP: willingness to pay

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