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E-health use, vaccination knowledge and perception of own risk: Drivers of vaccination uptake in medical students

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ABSTRACT

Objective: was to improve understanding of mechanisms contributing to healthcare personnel's (HCP) reluctance to get vaccinated against seasonal influenza. We assessed the role of several drivers: vaccination knowledge, vaccination recommendations and the role of the Internet (so-called e-health) in creating vaccination knowledge. The key mechanism under consideration was the perceived own risk (regarding disease and the vaccine).
Method: 310 medical students at the Frankfurt University Hospital answered an anonymous questionnaire assessing risk perceptions, intentions to get vaccinated, knowledge, preferences regarding information sources for personal health decisions and search-terms that they would use in a *Google*-search directed at seasonal influenza vaccination.
Results: The key driver of vaccination intentions was the perceived own risk (of contracting influenza and of suffering from vaccine adverse events). The recommendation to get vaccinated was a significant, yet weaker predictor. As an indirect driver we identified one's knowledge concerning vaccination. 32% of the knowledge questions were answered incorrectly or as don't know. 64% of the students were e-health users; therefore, additional information search via the Internet was likely. An analysis of the websites obtained by *googling* the search-terms provided by the students revealed 30% commercial e-health websites, 11% anti-vaccination websites and 10% public health websites. Explicit searches for vaccination risks led to fewer public health websites than searches without risk as a search term. Content analysis of the first three websites obtained revealed correct information regarding the questions of whether the doses of vaccine additives were dangerous, whether chronic diseases are triggered by vaccines and whether vaccines promote allergies in 58%, 53% and 34% of the websites, respectively. These questions were especially related to own risk, which strongly predicted intentions. Correct information on vaccination recommendations were provided on 85% of the websites.
Conclusion: Concentrating on the key drivers in early medical education (own risk of contracting influenza, vaccine safety, vaccination recommendation) promises to be a successful combination to increase vaccination uptake in HCP.

1. Introduction

Nosocomial influenza outbreaks occur frequently in healthcare settings [1]. Vaccination of healthcare personnel (HCP) is recommended as a strategy for preventing the spread of influenza. However, despite these official recommendations – e.g. from the Centers for Disease Control and Prevention (CDC) in the U.S.A and the Robert Koch Institute (RKI) in Germany – and the availability of an effective, well-tolerated vaccine, low seasonal and pandemic influenza vaccine acceptance among HCP is a problem detailed in many studies from all over of the world [2]. Recently, the Global Action Plan for Influenza Vaccines (GAP II) of the WHO formulated the goal to increase acceptance of influenza vaccinations among HCP for their own protection as well as the protection of others, as HCP are key multipliers due to their major influence on uptake in the population (e.g. of pregnant women [3]). Medical students will be the future healthcare workers and belong to HCP (based on a definition of the US Department of Health and Human Service HCP[1]).

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[1] "HCP refers to all paid and unpaid persons working in healthcare settings who have the potential for exposure to patients and/or to infectious materials, including body substances, contaminated medical supplies and equipment,

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Table 1
Descriptive statistics of perceived risks of influenza and AEFI (adverse events following immunization), vaccination intentions and vaccine-related knowledge. Sample $N = 310$ medical students.

Dependent variable (range)	*N*	*M*	*SD*	Mode	Meaning[a]
Probability influenza (1–7)	309	3.44	1.090	4	moderate
Severity influenza (1–7)	309	4.34	0.885	4	moderate
Risk influenza (1–49)	308	15.14	6.09		–
Probability AEFI (1–7)	307	3.23	1.055	3	low
Severity AEFI (1–7)	309	3.28	1.095	4	moderate
Risk AEFI (1–49)	306	11.30	6.33		–
Influenza vaccination intention (1–7)	310	3.75	1.754	3	rather not vaccinate
Knowledge score (sum; 0–9)	310	6.08	2.07	7	–

[a] *Note*: Semantic meaning of the mode as provided in the original questionnaire.

1.1. Aims and research questions

The purpose of the current study was to assess the drivers for medical students' vaccination uptake in order to improve future vaccination rates among HCP. We assessed vaccine-related knowledge as a potential driver, as more correct knowledge has been found to be related to higher vaccination rates [4,5]. We also assessed the impact of the official vaccination recommendation (by the German Standing Committee on Vaccination, STIKO). Because the use of the Internet as a source of health information is increasingly widespread [6,7], we also explored the role of the Internet in forming knowledge about vaccination as well as in delivering vaccine-critical information [8]. As a potential mechanism we explored the perceived own risk (of contracting influenza and of suffering from adverse events following immunization (AEFI)) in relation to vaccination intentions. In previous studies, medical students estimated their own risk of contracting influenza as lower than did physicians or nurses [9]; nearly a quarter were unaware of the official recommendation to get vaccinated against influenza [10]. Therefore, we will focus on the perceived own risk as a predictor of protection behavior [11,12]. Learning more about the drivers and mechanisms of medical students' influenza vaccination decision will help improve medical students' education schedule as well as their vaccination uptake.

2. Method

2.1. Study population

The study was conducted at the Frankfurt University Hospital, which is a 1169-bed hospital with 4055 employees (inter alia 1050 physicians and scientists, 1380 nurses and 930 medical technicians) covering 25 medical disciplines and research departments. At the Frankfurt Medical School, there are approximately 3350 medical and dental students, including 1200 medical students who are in the clinical phase of their studies. The questionnaire was distributed during the regular occupational health checkup, which is scheduled before the preliminary medical examination and clinical curriculum (4th semester).

2.2. Ethical considerations

Participants were informed that all information gathered would be anonymous and handled confidentially. Participation was voluntary; completion of the questionnaire implied consent for study participation. Participants cannot be identified from the material presented; and the study has caused no plausible harm to participating individuals.

2.3. Questionnaire

The anonymous questionnaire began with demographic questions. All item-ratings described in the remainder were collected on fully labeled 7-point scales unless stated otherwise. The perceived risk of contracting influenza during the upcoming season and the perceived risk of AEFI were assessed with two questions each concerning perceived probability and severity. The intention to vaccinate against influenza in the upcoming season was followed by a knowledge test [4] (9 statements to be rated as true, false or don't know) and one item of the same format assessing whether the students were aware of the influenza vaccination recommendation by the STIKO for HCP. The importance of nine different sources of health information was rated on a five-point scale [6]; and the frequency of Internet use for personal health questions on a fully labeled 6-point scale (1 = less than once a year; 6 = daily). Finally, students entered the search terms they would use to obtain information about the influenza vaccination in the upcoming season into an empty *Google*-text box.

3. Results

328 students took part in the obligatory check-up. 310 medical students (94.5% of the students in the checkup) completed the questionnaire (67.7% were female; $M_{age} = 22.19$ ($SD = 2.613$) years).

3.1. Risk perception

Most medical students perceived a moderate probability of contracting influenza and perceived influenza to be a moderately severe illness ('moderate' refers to the label given to the modal score 3 in the questionnaire; cf. Table 1). They expected a low probability of experiencing AEFI, which they perceived to be of moderate severity. Table 1 displays the descriptive statistics for the probability and severity components of risk as well as the mathematical product. In the remainder, we refer to the product term of probability and severity when discussing *risk* [13,14].

3.2. Vaccination intention

The mean vaccination intention was below the scale midpoint (mode = 3; cf. Table 1), indicating that the majority of students did not intend to get vaccinated in the upcoming season, even though they were going to have close contact with hospital patients.

3.3. Knowledge

Table 2 provides an overview of the answers to each question. Each of the ten answers was coded as correct or incorrect. When

contaminated environmental surfaces, or contaminated air. HCP might include (but are not limited to) physicians, nurses, nursing assistants, therapists, technicians, emergency medical service personnel, dental personnel, pharmacists, laboratory personnel, autopsy personnel, students and trainees [. . .]." Available at: http://www.hhs.gov/ash/initiatives/vacctoolkit/definition.html.

Table 2
Percentage of correct, false and don't know answers in the knowledge test. Sample $N = 310$ medical students.

	Item	% correct answers (*N*)	% false answers (*N*)	% don't know (*N*)
1	The additives used in vaccines are not dangerous for humans. (true)	50.6 (157)	20.0 (62)	29.4 (91)
2	Diseases like autism, multiple sclerosis and diabetes might be triggered by vaccinations. (false)	55.8 (173)	6.8 (21)	37.4 (116)
3	Vaccinations increase the occurrence of allergies. (false)	45.8 (142)	15.8 (49)	38.4 (119)
4	Vaccines are superfluous, as diseases can be treated, e.g. with antibiotics. (false)	92.6 (287)	1.3 (4)	6.1 (19)
5	Without mass vaccination programs, smallpox would still exist. (true)	76.1 (236)	5.2 (16)	18.7 (58)
6	The efficacy of vaccines has been proven. (true)	91.3 (283)	2.3 (7)	6.5 (20)
7	Children would be more resistant if they were not always vaccinated against all diseases. (false)	69.7 (216)	9.4 (29)	21.0 (65)
8	Many vaccinations are administered too early. As a result, the body's own immune system has no possibility to develop by itself. (false)	68.7 (213)	7.7 (24)	23.5 (73)
9	The immune system of children will not be overwhelmed by a high number of vaccines. (true)	58.1 (180)	16.8 (52)	25.2 (78)
(10)	The Standing Committee on Vaccination (STIKO) recommends influenza vaccination for health care workers. (true)	63.5 (197)	3.5 (11)	32.9 (102)

Note: Missing data was coded as don't know. Questions 1–9 are from [4].

calculating the knowledge score, we coded missing or 'don't know' answers as incorrect [4]. The total number of correct answers yields the total knowledge score (range 0–9; Cronbach's alpha in this sample = 0.69). There were no reliable gender differences ($p > 0.10$). Most of the questions were answered either correctly or as don't know; thus, the degree of explicitly false knowledge was quite low, while the amount of lacking knowledge was quite high. Most wrong or don't know answers concerned the additives contained in vaccines (49%). Further, 38% did not know whether vaccines promote allergies, while 37% did not know whether the emergence of chronic illness could be related to vaccines. 33% of the medical student sample did not know whether there was an official recommendation by the STIKO for HCP to get vaccinated against influenza.

3.4. Drivers of vaccination intentions

In order to assess whether single knowledge items were directly related to vaccination intentions, we conducted a regression analysis including the ten dichotomous knowledge questions (correct = 1, wrong or don't know = 0) as predictors and intention as the dependent variable. The analysis revealed that knowing the correct answer to questions 1 ($\beta = 0.11$, $p < 0.06$), 3 ($\beta = 0.13$, $p < 0.05$) and 10 ($\beta = 0.22$, $p < 0.001$) was (marginally) significantly related to vaccination intentions ($R^2 = 0.082$). Thus, among all knowledge questions, especially the false beliefs that vaccines contain dangerous additives and promote allergies were related to lower vaccination intentions. Moreover, the strongest predictor for low vaccination intentions was a lack of knowledge about the STIKO recommendation.

A path model (Fig. 1a) was calculated by means of a series of regressions, in order to assess the direct and indirect effects of total knowledge on vaccination intentions. Two separate regressions revealed that knowledge was positively related to perceived risk of contracting influenza ($\beta = 0.15$, $p < 0.01$) and negatively related to perceived AEFI risk ($\beta = -0.18$, $p < 0.001$). A third regression showed that the intention to get vaccinated was strongly influenced by the perceived risk of contracting influenza ($\beta = 0.47$, $p < 0.001$). The perceived risk of adverse-events also predicted intentions significantly – a higher perceived risk of adverse events was related to lower vaccination intentions ($\beta = -0.35$, $p < 0.001$). There was no direct relation between the total amount of correct knowledge and the intention to get vaccinated ($\beta = 0.05$, n.s.). Thus, knowledge seems to be an indirect driver of vaccination intentions, while the key mechanism is perceived own risk.

As an additional driver, we assessed the independent contribution of correct knowledge regarding the recommendation that HCP get vaccinated (Fig. 1b). Only participants who either knew or did not know that there was a recommendation were included; 11 participants who provided the wrong answer were excluded. While knowledge about the recommendation had a small but significant impact on intentions, perceived own risk (both to contract influenza and to suffer from side-effects) had a much larger relative impact. Knowledge again indirectly affected the intention to vaccinate by altering risk perceptions.

As knowledge appeared to be relevant by affecting risk perceptions, we will analyze which sources medical students access to gain knowledge concerning personal health decisions and whether preferences for certain sources are related to greater misperceptions about vaccination (i.e. less knowledge).

Table 3
Mean rated importance of different information sources for personal health decisions.

Source	Men $N = 100$		Women $N = 209$		Total $N = 309$	
	M	SD	M	SD	M	SD
Health professionals$_a$	4.11	0.898	4.27	0.903	4.22	0.903
Reference books$_a$	4.13	1.012	4.15	0.940	4.15	0.963
Books$_b$	3.81	1.158	3.94	0.959	3.90	1.027
Internet$_b$	3.68	0.994	3.87	0.944	3.81	0.963
Courses and lectures$_c$	3.51	1.133	3.63	0.966	3.59	1.023
Family, friends, and colleagues$_d$ *	3.19	1.042	3.51	0.990	3.41	1.016
Pharmacies$_e$ *	3.04	1.145	3.30	0.980	3.21	1.041
Newspapers and magazines$_e$	3.10	1.020	3.06	0.988	3.07	0.997
TV/radio$_f$	2.67	0.954	2.73	0.942	2.71	0.945

Note: categories with the same subscript do not differ significantly from each other (in the total column) as derived from comparing overlapping 95% CIs. * indicates significant gender differences ($p < 0.05$).

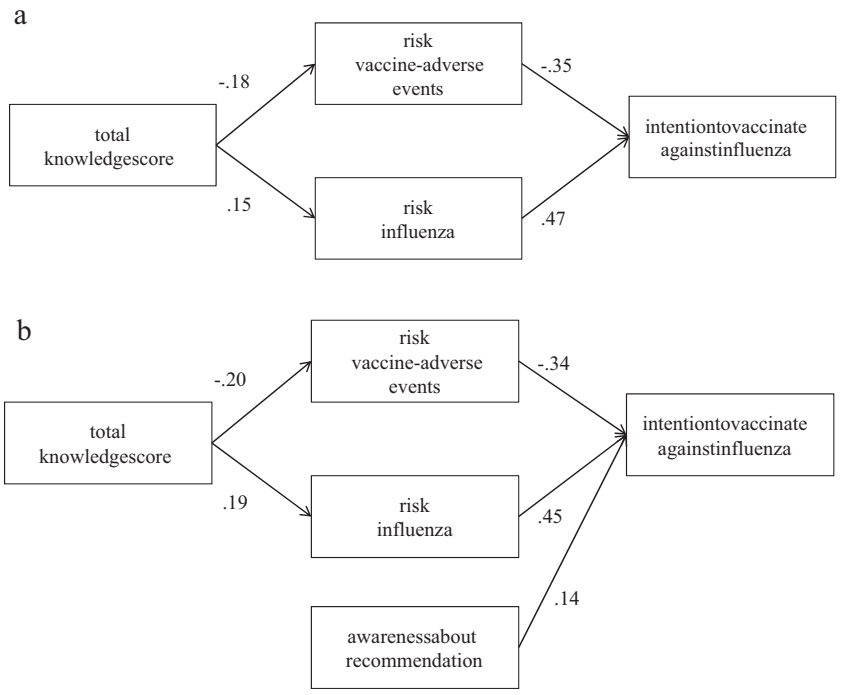

Fig. 1. (a) Path model depicting the indirect effects of knowledge (via risk perceptions) on the vaccination intention. *Note*: all *ß*-coefficients are significant at the $p < 0.05$ level. $N = 310$. (b) Path model depicting the additional effect of awareness of the vaccination recommendation on vaccination intentions. *Note*: all *ß*-coefficients are significant on the $p < 0.05$ level. $N = 292$.

3.5. Sources of health information for personal health decisions

The medical students in the present sample rated health professionals and reference books as the most important sources of information for personal health decision making. Non-reference books and the Internet were rated as significantly less important but were still included in the second most important group of sources (see subscripts in Table 3). The least important source was television or radio. Women rated family, friends and colleagues as more important sources than men did ($F(1, 305) = 6.90$, $p < 0.01$). Likewise, pharmacies were more important for women than for men ($F(1, 307) = 4.15$, $p < 0.05$). All other sources were rated as equally important by both genders ($Fs < 2.7$, $p < 0.10$). 195 students (63.5%) rated the Internet as an important or very important source of health information.

Because the use of the Internet as a source of health information is increasingly widespread, the next section explores the role of the Internet in influencing potential misperceptions concerning vaccination as well as in delivering vaccine-critical information.

3.6. The Internet as a source of vaccination knowledge

Obtained websites. For each participant, we "*googled*" the search terms (June 2011) provided on the questionnaire, in order to assess the information environment that the student would face following such a search. As users typically select websites obtained on the first page of hits [15,16], we categorized the first ten hits according to their source. Results are displayed in Table 4. Vaccine-critical websites were slightly more likely to occur on the first page than public health websites. Most websites were commercial websites. The modal rank of the first anti-vaccination website on the hit list was 7 (for participants who obtained anti-vaccination websites; mean rank = 5.57, $SD = 2.20$).

3.7. Quality of obtained information

In order to assess the amount of correct and incorrect information that the medical students would obtain in their web-searches, we searched the first three websites in the *Google* hit list for answers to the questions of (question no. 1) whether the dosage of additives contained in vaccines is dangerous for humans; (2) whether the emergence of chronic illnesses are related to vaccines; (3) whether vaccines promote allergies; and (10) whether there is a recommendation for HCP to get vaccinated against influenza. We examined only the first three websites, as these are the websites that users are most likely to open following an online search [17]. A maximum of 4 clicks on each page was used to determine whether the answer to each question was provided correctly, incorrectly or not at all [18]. We selected these particular questions because they: (i) had high rates of 'don't know' answers, making knowledge acquisition therefore seem likely and relevant (see Table 1); and (ii) are relevant to risk perception and decision making, as the results reported previously showed that own risk had the highest impact on vaccination intentions. Table 5 provides the percentages of websites that provided correct, incorrect or no answers for the entire sample of analyzed websites as well as for a subsample of websites that contained at least one anti-vaccination website. 88.5% of all websites provided correct information regarding the recommendation of influenza vaccinations for HCP. We found no explicit misinformation; however, 11.5% of the websites did not provide information on this topic. The percentage of websites providing correct answers to the remaining three questions was low (34%) to medium (58%). Especially in terms of the question of whether vaccines promote allergies, information was lacking on 65% of the websites. Explicit misinformation was typically found when anti-vaccination websites were among the first three hits; especially the idea of vaccines being contaminated with dangerous additives was promoted on anti-vaccination websites [8].

Table 4
Classification of the first ten websites obtained in a *Google* search using search terms provided by a sample of 310 German medical students. Total sample of websites $N = 3100$.

Category	Percentage of websites of this category in the total sample of websites (*N* websites)	Percentage of participants who obtained at least one website of this category (*N* participants)
Commercial e-health websites	29.97 (929)	99.03 (307)
Wikipedia (or other online-lexicon)	18.42 (571)	90.65 (281)
News providers	19.00 (589)	88.39 (274)
Vaccine-critical or anti-vaccination	10.87 (337)	72.58 (225)
Manufacturer	6.26 (194)	56.77 (176)
Public health players	10.10 (313)	54.52 (169)
University or research	2.10 (65)	19.35 (60)

Note: 2.35% of the websites were not related to human vaccination (e.g. animal vaccination) and were therefore disregarded. If column sums do not add up to the total *N*, missing values were Internet pages that were unrelated to human vaccination.

3.8. Obtained websites after searches of risk

6.5% of the participants explicitly searched for risks related to influenza vaccination (e.g. by including 'adverse events' in the search string). We conducted a repeated measurement analysis of variance with the number of anti-vaccination websites and public health websites obtained from the fictitious searches as dependent variables and a dummy variable coding whether risk was included in the search terms. The analysis showed that while there was only a small difference in the number of anti-vaccination websites that surfaced after searching for risk ($M = 1.07$ ($SD = 0.84$) for search strings unrelated to risk and $M = 1.25$ ($SD = 1.45$) for strings with risk terms), the difference in the number of obtained public health websites was of considerable magnitude: when risk was included in the search string, the mean number of public health websites found was $M = 0.25$ ($SD = 0.72$); when risk was not part of the search string, $M = 1.06$ ($SD = 1.30$) public health websites were found (interaction $F(1, 308) = 5.88$, $p < 0.05$).

3.9. Knowledge and the likelihood of finding anti-vaccination websites

Downs et al. [5] claimed that that parents who are less knowledgeable are especially prone to find vaccine-critical websites. In order to test if this also holds for medical students we tested if knowledge and other additional search-term related factors determine whether anti-vaccination websites are among the first three of the hit list. Therefore, we conducted a binary logistic regression with knowledge, the number of search terms used and a dummy variable that coded if risk was explicated in the search term as predictors. A greater number of search terms was related to a higher probability of anti-vaccination websites ($B = 0.79$, Wald = 12.87, $p < 0.001$). Furthermore, participants with more accurate knowledge were less likely to obtain anti-vaccination websites ($B = -0.17$, Wald = 3.97, $p < 0.05$). Whether participants explicitly searched for vaccination risks was not related to the number of anti-vaccination websites found.

4. Discussion

The current study revealed that medical students' perceptions of their own risk (both of contracting influenza and suffering from side-effects) were major drivers of their vaccination intentions, as they had a greater impact on intentions than the official recommendation of the German Standing Committee on Vaccination that HCP get vaccinated. These findings are in line with psychological theories of preventive behavior that propose that the perception of risk is a central predictor of protection intentions and preventive health behavior [11,19,20]. Thus, all factors affecting perceptions of own risks are likely to become indirect drivers: they may indirectly influence vaccination intentions and subsequent vaccination behavior [21–25]. In this study, greater correct knowledge about vaccination indirectly affected the intention to vaccinate by increasing influenza risk perceptions and decreasing the perceived risk of vaccine adverse events [4,26]. The present study also demonstrates a lack of vaccination knowledge in this particular sample of medical students. However, it should be mentioned that "virology lectures" and "infectious diseases lectures" are not included in the 2nd year curriculum. Knowledge regarding potential side-effect and immunological relations was especially lacking.

Knowledge about an existing official recommendation to get vaccinated also impacts vaccination intentions, as it sets a norm [22], e.g. for a certain group of people such as HCP. Awareness of this recommendation is crucial during the transition period between sitting in a classroom, where the recommendation does not apply, and taking responsibility for patients. While the majority (63%) was aware of the recommendation, such awareness was only weakly

Table 5
Percentage of websites providing a correct, false or no answer to four selected questions. The first three websites found in the *Google* searches using the students' search terms were used for this content analysis.

question (answer)		% correct answers (*N*)	% false answers (*N*)	% no answer (*N*)
Are the additives used in vaccines dangerous for humans? (no)	total sample	58.4 (541)	7.1 (66)	34.4 (319)
	anti-vaccination subsample*	27.5 (28)	21.6 (22)	51.0 (52)
Do vaccines trigger diseases like autism, multiple sclerosis and diabetes? (no)	total sample	53.6 (493)	2.4 (22)	44.0 (405)
	anti-vaccination subsample*	32.0 (32)	15.0 (15)	53.0 (53)
Do vaccinations increase the occurrence of allergies? (no)	total sample	34.1 (315)	0.4 (4)	65.4 (604)
	anti-vaccination subsample*	14.7 (15)	1.0 (1)	84.3 (86)
Is there a recommendation for HCP to get vaccinated against influenza? (yes)	total sample	88.5 (818)	0.0 (0)	11.5 (106)
	anti-vaccination subsample*	55.9 (57)	0.0 (0)	44.1 (45)

Note: Total $N = 930$ analyzed websites. * subsample with anti-vaccination website among the first 3 hits, N = 102 websites. If row sums do not add up to the total *N*, missing values were Internet pages that were unrelated to human vaccination.

related to vaccination intentions; and intentions were low. Thus, simply relying on the motivating power of recommendations seems less promising than educating students early about their own risk as well as their obligation to protect others [23].

The amount of correct knowledge people have about vaccination may vary according to the information sources that are used for personal health decisions, e.g. the Internet. Users prefer search engines (such as *Google*) rather than directly approaching specific e-health websites [5,13]. In the present study, an analysis of the first ten websites that resulted from *Google* searches using the search terms provided by the participants revealed that public health websites occurred with roughly the same probability as anti-vaccination websites (10 vs. 11%, respectively). Especially students who used risk-related search terms were less likely to obtain reliable information from public health websites. A content analysis of the first three websites revealed that only a third to somewhat more than half of the websites provided correct information regarding vaccine safety questions. This is in line with previous work demonstrating that the quality of the information obtained with search engines varies dramatically [18,27]. Individuals with less knowledge also had a higher likelihood of finding anti-vaccination websites. Even brief visits to such websites alter risk perceptions and lower vaccination intentions [28].

5. Conclusion

The low rates of influenza vaccinations among HCP have been a concern for some time and pose a serious health threat to vulnerable patient populations. Medical students belong to a group of HCP that is frequently exposed to patients and potentially also to occupationally transmissible infectious diseases. For this reason, achieving high influenza vaccination coverage will protect both HCP and their patients. However, the majority of the medical students in our sample did not intend to get vaccinated in the upcoming influenza season. The mechanism, or key driver, underlying this was perceived own risk, which was the major predictor of vaccination intentions. The recommendation to get vaccinated was a significant, yet weaker driver. As an indirect driver we identified knowledge concerning vaccination. Additional efforts to educate medical students regarding their own risk of contracting influenza along with information about vaccination safety and official recommendations are needed *early* in medical training. The majority of the medical students assessed in this study were e-health users. Thus, early information may prevent students from relying on the Internet as an information source for the vaccination decision. The analysis of the websites revealed that important information was missing on a third to half of the analyzed websites, while misinformation about immunization and vaccine safety can be promoted by Internet searches [8] and may influence vaccination intentions via increasing vaccine risk perception [28]. Because the Internet is an important source of health information, public health websites, though less frequent, should also consider search engine optimization (e.g. increasing the number of inbound links or content relevance to specific keywords [29]) in order to make themselves easier to find, especially for less knowledgeable people who are in need of reliable information about the risks and benefits of vaccination.

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