The intent of students to vaccinate is influenced by cultural factors, peer network, and knowledge about vaccines

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ABSTRACT
Young adults are the future vaccine decision-makers as parents or health-care professionals. To understand their attitudes and behaviors toward vaccination, we conducted a cross-sectional survey of 2079 students attending the University of Antwerp, Belgium, and the University of Pisa, Italy. Principal component analysis was used to investigate associations between survey responses and the intent to vaccinate. Vaccination knowledge, attitudes, and behaviors among university students in Italy and Belgium were high. However, only one-half of respondents displayed an intent to vaccinate. High levels of knowledge, positive attitudes, and confidence in vaccines were positively associated with age, higher level of study, being a medical student, a recent vaccination experience, and not knowing trusted persons who did not believe in vaccines. Country of origin was highly correlated with the survey responses and was clustered with lifestyle, family, and data source variables, suggesting a strong modifying effect of culture and family attitudes on how vaccines are perceived in this age-group. Recent meningococcal vaccination campaigns and public discussions around mandatory vaccination in Italy may have influenced these results. We show that the intent to vaccinate was correlated with two main clusters of variables linked to culture (country, family, lifestyle), and to scholarship (knowledge, attitudes, data source) that together influence the behavior of students with respect to vaccination. Our study reinforces previous findings that knowledge about vaccines is key to shaping attitudes and behaviors, but also shows that cultural and lifestyle factors are another platform that could be leveraged in promoting vaccination among young people.

Introduction
Vaccines are a high-value public health intervention that prevent 2–3 million child deaths annually. Nonetheless, immunization programs face substantial ongoing challenges in achieving target coverage rates, and outbreaks of preventable diseases continue to be widely reported. The persistent measles outbreaks in Europe since 2016 accentuate the drawbacks of suboptimal vaccination coverage levels in the region, where 78% of reported cases occur in non-vaccinated individuals. In 2019, only four countries in Europe had measles vaccine coverage of 95% or more, which is the level needed to interrupt disease transmission. Health experts have attributed outbreaks of vaccine-preventable diseases to increasing vaccine hesitancy behaviors and negative attitudes toward vaccination, suggesting that vaccination coverage rates are in part a reflection of individual vaccination attitudes and behaviors. One theory is that individuals will adopt protective vaccination behaviors when they perceive they are at risk. In many cases, however, the necessity of vaccination is questioned due to lack of awareness of the disease, poor knowledge about its potential consequences, and a perception of low disease susceptibility. Further, the success of vaccination programs has encouraged complacency about diseases that most individuals have never experienced or heard little about.

Vaccination behaviors can be influenced by beliefs in the safety and protective action of the vaccine as well as the perceived benefits of getting vaccinated. These beliefs can become distorted by unsubstantiated misinformation about the risks posed by vaccination. Since health-care providers (HCPs) are the most commonly accessed resource for vaccine-related information, interactions with health professionals are important determinants of vaccination consent and adherence. As with other health behaviors, social norms and networks exert powerful influences on vaccination attitudes and behaviors, and individuals may align their vaccination decisions with those of their family members and members of their social network. This explains why negative attitudes toward vaccination sometimes cluster geographically.

While many studies examine parental knowledge, beliefs, and attitude toward vaccination, perceptions and behaviors toward vaccination in young adults remain less well described, with the exception of several published studies focusing on specific vaccinations such as HPV and influenza. Young adults, however, represent the population of future parents who will take vaccination decisions for their own
children. Young adults are also future HCPs who will communicate vaccine benefits and counsel individuals who express doubt about vaccines.

The primary objective of this study was to investigate attitudes and behaviors toward vaccination among students at the University of Antwerp, Belgium and the University of Pisa, Italy. We also aimed to examine vaccination behaviors of students studying in medical and non-medical disciplines in order to understand if educational background was predictive of positive vaccination attitudes. Describing the relationship among these different factors can provide new insights on factors that influence vaccine acceptance and suggest possible behavioral interventional strategies to address public confidence in vaccines.

Methods

Study setting and population

The data for this cross-sectional study were collected between April and July 2018. Study participants were students attending different faculties at the University of Antwerp, Belgium and the University of Pisa, Italy. The University of Pisa has about 50,000 students across 20 departments, whereas the University of Antwerp educates 20,000 students across 9 departments. In order to achieve 95% confidence level and 5% margin of error, the adequate sample size should be at least 759 (377 per the Belgian and 382 respondents per the Italian site).18 Considering the particular interest of recruiting a sufficient number of medical students to evaluate their responses versus the non-medical group, the recruitment was stopped when 800 medical students completed the survey, in order to compensate for any potential incomplete answers. Respondents were recruited through an invitation link to the study questionnaire posted to online student groups and university noticeboards. The questionnaire was administered anonymously and required an average of 15 minutes to complete. The survey remained open for at least 1 month due to the slow recruitment rate.

In order to explore the effectiveness of an alternative recruitment strategy, students attending the University of Antwerp campus were additionally invited by a researcher during their break-out periods to attend face-to-face focus groups of 5–10 run by a single interviewer. The focus groups were run on a single day during a visit by OL to the University of Antwerp campus who approached and recruited students individually. Interviews were conducted concurrently with the on-line survey.

The study was approved by the research institutions participating in this study.

Questionnaire design

The self-administered questionnaire consisted of 30 items and was designed based on findings from previous studies and relevant literature.5,19–21 The Health Belief Model underpinned the construction of the survey questions, as this has proven to be particularly effective in understanding vaccination attitudes and predicting vaccination behaviors.21,22 The questionnaire was divided into five sections:

1. Baseline questions recorded age, gender, area, level of study, lifestyle, timing of the most recent vaccination, and age of the next vaccination and were answered using multiple choice or free text. An additional question was asked if among the people I trust, there are some that do not believe in vaccination and was answered using a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree) in the on-line survey, and a binary option (agree or disagree) during the face-to-face interviews, with responses combined into a composite variable for the analysis.

2. Vaccine knowledge questions were designed based on empirical vaccine-related information relating to the public health benefits of vaccination. The six questions were scored on a 5-point Likert scale (strongly agree, agree, neutral, disagree, strongly disagree) and the responses categorized into ‘correct answer’ versus ‘incorrect answer’ (including neutral or no response). A score of “1” was given for each correct answer and “0” for incorrect or unknown answer.23 The total possible knowledge score for each respondent ranged from 0 to 6.

3. Attitude toward vaccination questions is designed to assess how participants perceived benefits, barriers, and influences of vaccination. The six questions (3 pro and 3 contra-trait) were scored items on a 5-point Likert scale (from 1 “strongly disagree” to 5 “strongly agree”) and reverse coding was applied for statements that were negatively worded.5 A total attitude score ranging from 6 to 30 points was calculated per respondent.

4. Vaccine confidence questions included three items adapted from the vaccine confidence scale developed by Heidi Larson.24 The questions were scored items on a 5-point Likert scale from 1 “strongly disagree” to 5 “strongly agree” and a total confidence score ranging from 3 to 15 points was calculated per respondent.

5. Sources of vaccine-related information which was assessed using a single multiple choice item were modified from a similar survey conducted by Jones.25

The final questionnaire was validated in the focus groups and the data collected have been included into the data analysis indicating the data source.

Data analysis

Descriptive statistics were used to analyze sample characteristics. Chi-square tests were performed to examine differences in survey responses for all singular items of the vaccine knowledge questionnaire, attitudes toward vaccination scale and vaccine confidence scale. Analysis of variance (ANOVA) or independent sample t test was used to examine the association between categorical predictors (gender, faculty, age) and continuous variables (vaccine knowledge, vaccine confidence, and attitudes toward vaccination).

The intent to vaccinate was determined as 1 = Yes or 0 = No if either of the following questions were answered at what age is my next vaccination? or what is the next vaccine that you plan to receive? Principal component analysis (PCA) was performed to explain the intent to vaccinate using the other variables collected, where
logit(Pr(intent to vaccinate)) = alpha + beta1*PC1 + beta2*PC2 + beta3*PC3 + other demographic variables

All analyses were performed using the statistical program SPSS Statistics for Windows v25 (SPSS v25, IBM Corp., Armonk, NY, USA).

Results
A total of 2079 participants completed the survey of whom 321 participated in face-to-face interviews. The sample included 873 medical students and 1206 students from other faculties. The principal characteristics of the study group are shown in Table 1. The majority of respondents (63.2%) were students in Italy and 36.8% attended university in Belgium. A total of 21.6% of respondents reported that they had trusted contacts who did not believe in vaccination.

Knowledge and perception of vaccination
Overall, knowledge and perception of the benefits of vaccination were high (Table 2). More than 90% of respondents provided correct responses to questions about herd immunity, the protective benefit of vaccination, relevance of vaccines across all ages, while a somewhat lower proportion (83.3%) understood the contribution of vaccination to small pox elimination in Europe.

The mean correct response over the six questions among respondents was 5.51 (91.8%). Knowledge was significantly higher among respondents in Italy (mean correct response 5.72/6, 95.3%) than participants in Belgium (5.14, 85.7%); p < .001 (Table 3). Students of medicine scored significantly higher (5.78, 96.3%) compared to non-medical students (5.31, 88.5%); p < .001.

Attitudes toward vaccination
In total, 94.1% of respondents believed that getting vaccinated was a moral responsibility to protect others (Table 4). However, 8.2% felt vaccines should no longer be necessary for diseases that have become uncommon. The majority of respondents (68.8%) disagreed with the assumption that vaccination is promoted by the pharmaceutical industries for profit reasons. 86.4% expressed their willingness to acquire more information regarding their recommended vaccines.

The mean total value of young adults’ attitudes regarding vaccination was 23.29 (77.6%) on the 30-point scale. Medical students differed significantly in all attitudes compared to non-medical students (total score 23.75, 79.2% versus 22.95, 76.5%); p < .001. Participants with trusted contacts against vaccines had significantly lower mean attitude scores (22.61, 75.4% versus 23.68, 78.9%; p < .001).

Level of vaccine confidence
In total, 93.4% of respondents considered vaccines to have an acceptable safety profile, 87.7% considered that vaccines are important to them, and 95.6% believed that vaccines are effective (Table 5). Only 2.3% of respondents disagreed that vaccines are safe, and 2.2% disagreed that vaccines are effective.

The mean vaccine confidence score among all respondents was 13.20 on the 15-point scale (88%). Older and medical students were significantly more confident about vaccination than the younger and non-medical respondents (Table 3). A recent history of vaccination was another positive factor contributing to vaccine confidence. Interestingly, participants

### Table 1. Characteristics of the survey respondents.

| Country     | N    | %        | p-Value |
|-------------|------|----------|---------|
| Italy       | 1313 | 63.2     | <0.001  |
| Belgium     | 766  | 36.8     |         |
| Gender      |      |          |         |
| Male        | 591  | 28.4     | 0.337   |
| Female      | 1485 | 71.4     |         |
| Prefer not to say | 3   | 0.1      |         |
| Faculty     |      |          |         |
| Medical Science | 873| 42.0     | <0.001  |
| Non-Medical Science | 1206| 58.0 |
| Age Range   |      |          |         |
| 18–20 years | 470  | 22.6     | <0.001  |
| 21–24 years | 1026 | 49.4     |         |
| ≥25 years   | 583  | 28.0     |         |
| Study level |      |          |         |
| Bachelor    | 886  | 42.6     | <0.001  |
| Master      | 1134 | 54.5     |         |
| Doctorate   | 59   | 2.8      |         |
| Knowing someone opposed to vaccination | | |
| No          | 1193 | 57.4     | <0.001  |
| Neutral     | 438  | 21.0     |         |
| Yes         | 448  | 21.6     |         |

### Table 2. Knowledge and perception of vaccines among respondents.

| Statement                                                                 | Response | Medical (N = 873) | Non-Medical (N = 1206) | Total (N = 2079) | p-Value |
|--------------------------------------------------------------------------|----------|-------------------|------------------------|------------------|---------|
| Q1 – Small pox and Polio in Europe have been eliminated because of vaccination | Correct answer | n (%)              | n (%)                  | n (%)           | p < .001 |
| Q2 – I believe vaccines are only relevant for children                   | Correct answer | 846 (97.0)         | 1125 (93.8)            | 1971 (95.1)     | p < .001 |
| Q3 – More people should be vaccinated against diseases that are dangerous | Correct answer | 842 (96.6)         | 1026 (85.4)            | 1868 (90.1)     | p < .001 |
| Q4 – Vaccines can protect me against diseases that are quite dangerous  | Correct answer | 860 (98.6)         | 1150 (95.6)            | 2010 (96.8)     | p < .001 |
| Q5 – A good diet and a healthy lifestyle can keep me healthy, so I do not need vaccines | Correct answer | 847 (97.1)         | 1115 (92.7)            | 1962 (94.6)     | p < .001 |
| Q6 – Not having my vaccinations may increase the risk that I get infected | Correct answer | 840 (96.2)         | 1071 (88.4)            | 1911 (92.0)     | p < .001 |
with trusted contacts who were opposed to vaccination were significantly less confident in the safety and effectiveness of vaccines compared to those who reported they did not, showing the influence of the attitudes of their peers. The influence of the environment on vaccine confidence was further highlighted through the primary component analysis below.

Table 3. Relationship between level of vaccine knowledge, attitude toward vaccination and vaccine confidence.

| Variables                  | Vaccine knowledge mean (SD) | Attitude mean (SD) | Confidence mean (SD) |
|----------------------------|-----------------------------|--------------------|----------------------|
| Country                    |                             |                    |                      |
| Italy                      | 5.72 (0.6) ***              | 23.91 (2.8)***     | 13.65 (2.0)          |
| Belgium                    | 5.14 (1.2)                  | 22.22 (2.6)        | 12.43 (2.1)          |
| Gender                     |                             |                    |                      |
| Male                       | 5.53 (0.8)                  | 23.05 (3.0)        | 13.36 (2.0)          |
| Female                     | 5.50 (0.9)                  | 23.38 (3.0)        | 13.14 (2.1)          |
| Unknown                    | 5.51 (0.9)                  | 23.29 (2.8)        | 13.20 (2.1)          |
| Faculty of Study           |                             |                    |                      |
| Medical                    | 5.78 (0.6) ***              | 23.75 (2.5)***     | 13.90 (1.7)***       |
| Non-Medical                | 5.31 (1.0)                  | 22.95 (3.0)        | 12.70 (2.2)          |
| Age Range                  |                             |                    |                      |
| 18–20 years                | 5.26 (1.0)                  | 22.66 (3.1)        | 12.54 (2.3)          |
| 21–24 years                | 5.55 (0.8)                  | 23.37 (3.0)        | 13.28 (2.1)          |
| ≥25 years                  | 5.64 (0.8) ***              | 23.64 (2.6)***     | 13.60 (1.8)***       |
| Study Level                |                             |                    |                      |
| Bachelor                   | 5.31 (1.0)                  | 22.94 (3.1)        | 13.11 (2.2)          |
| Master                     | 5.66 (0.7) ***              | 23.59 (2.5)***     | 13.94 (1.7)***       |
| Doctorate                  | 5.56 (0.8)                  | 22.73 (4.0)        | 13.63 (2.8)          |
| Vaccination History        |                             |                    |                      |
| within last year           | 5.62 (0.8) ***              | 23.68 (2.8)***     | 13.48 (2.1)***       |
| <5 years ago               | 5.54 (0.8)                  | 23.28 (2.6)        | 13.33 (2.0)          |
| 5–10 years ago             | 5.43 (0.9)                  | 23.14 (2.6)        | 13.00 (2.6)          |
| >10 years ago              | 5.41 (1.0)                  | 23.10 (3.6)        | 12.33 (2.0)          |
| Can’t remember             | 5.14 (1.2)                  | 22.23 (3.1)        | 12.92 (2.7)          |
| Knowing someone opposed to |                             |                    |                      |
| vaccination                | 5.62 (0.7) ***              | 23.68 (2.4)***     | 12.81 (2.0)          |
| No                        | 5.39 (1.1)                  | 22.95 (2.9)        | 12.57 (2.5)          |
| Neutral                   | 5.35 (1.1)                  | 22.61 (3.3)        |                        |

*p < 0.05, **p < 0.01, ***p < 0.001

Table 4. Attitude toward vaccination among respondents.

| Statement                                                                 | Response            | Medical (N = 873) | Non-medical (N = 1206) | Total (N = 2079) | p-Value  |
|---------------------------------------------------------------------------|---------------------|-------------------|-------------------------|------------------|----------|
| Q1 – I don’t believe that all or some of the vaccines are still needed because the disease they protect against is already disappeared | Strongly agree      | 14 (1.6)          | 22 (1.8)                | 36 (1.7)         | p < .001 |
|                                                                           | Agree               | 51 (5.8)          | 84 (7.0)                | 135 (6.5)        |          |
|                                                                           | Neutral             | 89 (10.2)         | 212 (17.6)              | 301 (14.5)       |          |
|                                                                           | Disagree            | 291 (33.3)        | 462 (38.3)              | 753 (36.2)       |          |
|                                                                           | Strongly disagree   | 428 (49.0)        | 425 (35.3)              | 853 (41.0)       |          |
| Q2 – I feel that I do not have enough information about vaccines           | Strongly agree      | 28 (3.2)          | 88 (7.3)                | 116 (5.6)        | p < .001 |
|                                                                           | Agree               | 145 (16.6)        | 347 (28.8)              | 492 (23.7)       |          |
|                                                                           | Neutral             | 172 (19.7)        | 353 (29.3)              | 525 (25.3)       |          |
|                                                                           | Disagree            | 311 (35.7)        | 283 (23.5)              | 594 (28.6)       |          |
|                                                                           | Strongly disagree   | 216 (24.8)        | 134 (11.1)              | 350 (16.9)       |          |
| Q3 – Pharmaceutical companies only promote vaccines to make money         | Strongly agree      | 9 (1.0)           | 44 (3.7)                | 53 (2.6)         | p < .001 |
|                                                                           | Agree               | 36 (4.1)          | 106 (8.8)               | 142 (6.8)        |          |
|                                                                           | Neutral             | 134 (15.4)        | 315 (26.2)              | 449 (21.6)       |          |
|                                                                           | Disagree            | 298 (34.2)        | 424 (35.2)              | 722 (34.8)       |          |
|                                                                           | Strongly disagree   | 395 (45.3)        | 314 (26.1)              | 709 (34.2)       |          |
| Q4 – I need to be vaccinated to also protect others                        | Strongly agree      | 636 (72.9)        | 602 (50.0)              | 1238 (59.6)      | p < .001 |
|                                                                           | Agree               | 222 (25.4)        | 497 (41.2)              | 719 (34.6)       |          |
|                                                                           | Neutral             | 3 (0.3)           | 57 (4.7)                | 60 (2.9)         |          |
|                                                                           | Disagree            | 2 (0.2)           | 28 (2.3)                | 30 (1.4)         |          |
|                                                                           | Strongly disagree   | 10 (1.1)          | 21 (1.7)                | 30 (1.5)         |          |
| Q5 – I would like to know which vaccines I should have as an adult         | Strongly agree      | 364 (41.7)        | 473 (39.3)              | 837 (40.3)       | p = .023 |
|                                                                           | Agree               | 378 (43.3)        | 582 (48.4)              | 960 (46.2)       |          |
|                                                                           | Neutral             | 102 (11.7)        | 98 (8.1)                | 200 (9.6)        |          |
|                                                                           | Disagree            | 15 (1.7)          | 29 (2.4)                | 44 (2.1)         |          |
|                                                                           | Strongly disagree   | 14 (1.6)          | 21 (1.7)                | 35 (1.7)         |          |
| Q6 – I know where I can get my vaccination                                | Strongly agree      | 354 (40.5)        | 301 (25.0)              | 655 (31.5)       | p < .001 |
|                                                                           | Agree               | 327 (37.5)        | 528 (43.9)              | 855 (41.2)       |          |
|                                                                           | Neutral             | 114 (13.1)        | 182 (15.1)              | 296 (14.3)       |          |
|                                                                           | Disagree            | 57 (6.5)          | 159 (13.2)              | 216 (10.4)       |          |
|                                                                           | Strongly disagree   | 21 (2.4)          | 34 (2.8)                | 55 (2.6)         |          |
Table 5. Level of vaccine confidence among respondents.

| Statement                                                                 | Medical (N = 873) | Non-medical (N = 1206) | Total (N = 2079) | p-Value  |
|---------------------------------------------------------------------------|-------------------|-------------------------|------------------|----------|
| Q1 – In general, I think vaccines have an acceptable safety profile       | Strongly agree    | 557 (63.9)              | 459 (38.1)       | 1016 (48.9) | p < .001 |
| Agree                                                                    | 293 (33.8)        | 630 (52.3)              | 923 (44.5)       | 1213 (58.2) |       |
| Neutral                                                                  | 13 (1.5)          | 78 (6.5)                | 91 (4.4)         | 182 (8.8)  |       |
| Disagree                                                                 | 3 (0.3)           | 17 (6.5)                | 20 (1.0)         | 30 (1.4)   |       |
| Strongly disagree                                                        | 5 (0.6)           | 21 (1.7)                | 26 (1.3)         | 32 (1.5)   |       |
| Q2 – in general, vaccines are important to me                             | Strongly agree    | 604 (69.2)              | 490 (40.8)       | 1094 (52.7) | p < .001 |
| Agree                                                                    | 226 (25.4)        | 506 (41.2)              | 732 (35.3)       | 1258 (60.6) |       |
| Neutral                                                                  | 35 (4.0)          | 147 (12.2)              | 182 (8.8)        | 262 (12.6) |       |
| Disagree                                                                 | 2 (0.2)           | 30 (2.5)                | 32 (1.5)         | 34 (1.6)   |       |
| Strongly disagree                                                        | 6 (0.7)           | 29 (2.4)                | 35 (1.7)         | 41 (2.0)   |       |
| Q3 – In general, I think vaccines are effective                           | Strongly agree    | 633 (72.5)              | 545 (45.6)       | 1178 (57.0) | p < .001 |
| Agree                                                                    | 226 (25.9)        | 573 (47.9)              | 797 (38.6)       | 1520 (73.4) |       |
| Neutral                                                                  | 6 (0.7)           | 41 (3.4)                | 47 (2.2)         | 54 (2.6)   |       |
| Disagree                                                                 | 2 (0.2)           | 18 (1.5)                | 20 (1.0)         | 22 (1.0)   |       |
| Strongly disagree                                                        | 6 (0.7)           | 19 (1.6)                | 25 (1.2)         | 31 (1.5)   |       |

Intent to vaccinate

Respondents demonstrated a high level of awareness with respect to their vaccination history. The majority of the respondents could recall the last time they were vaccinated and only 7.3% (n = 151) could not remember when they had their last vaccination; 82.8% (n = 125) of these were non-medical students (Table 6). In total, 67.7% (n = 1407) reported to have received at least one vaccine within the last 5 years, and 6.0% (n = 125) received their last vaccination more than 10 years ago. Of the 634 (30.5%) participants who had received any vaccination in the previous year, 48.1% (n = 305) were within the age range of 21–24 years, 51.3% (n = 325) were medical students, and 62.8% (n = 398) were students of the Italian university.

Almost one-half of respondents (49.2%, n = 1023) indicated that they had either “no idea” or “no intention” to receive their next recommended vaccine and 72.6% (n = 743) of these respondents were non-medical students (Table 7). More females (75.9%, n = 801) than males 24.1% (n = 255) were aware of their next vaccination (p < .001). Compared to Belgium respondents, a significantly higher percentage of participants in Italy reported to know about/intered to receive their next recommended vaccine (25.0% vs 75.0%; p < .001). Those who had been vaccinated recently were more likely to be aware of their future vaccination; among the 1056 respondents who intended to receive their next vaccine, 72.9% (n = 770) had their most recent vaccination less than 5 years ago, while 16.6% (n = 174) had received their last vaccination between 5 and 10 years ago. Only 5.9% (n = 62) of the respondents who had not been vaccinated in last 10 years reported to be aware of their next recommended vaccine.

PCA on score data summarized two main components, PC1 and PC2, with PC1 explaining 17% of the variation (Figure 1). Country of origin and vaccine importance (in opposite directions reflecting the scoring convention) were the most significant determinants of the intent to vaccinate (Figure 1). The country of origin was correlated with lifestyle, family, and data-source factors, whereas vaccine importance was correlated with knowledge and attitude. Age was correlated more with knowledge than with lifestyle or data source. Social media, friends, gender, and level of fitness were not significant. The intent to vaccinate was significantly associated with age, gender, and PC1 (Table 8). The intent to vaccinate was also impacted by Datasource, with scores for vaccine knowledge and attitude

Table 6. Vaccination history among respondents.

| Variables                  | Within last year | <5 years ago | 5–10 years ago | >10 years ago | Cannot remember |
|----------------------------|------------------|--------------|----------------|---------------|-----------------|
|                            | n (%)            | n (%)        | n (%)          | n (%)         | n (%)           |
| Country                    |                  |              |                |               |                 |
| Italy                      | 396 (62.8)       | 500 (64.7)   | 222 (56.1)     | 111 (88.8)    | 82 (50.6)       |
| Belgium                    | 236 (37.2)       | 273 (35.3)   | 174 (43.9)     | 14 (11.2)     | 69 (45.7)       |
| Total                      | 634 (100)        | 773 (100)    | 396 (100)      | 125 (100)     | 151 (100)       |
| Faculty                    |                  |              |                |               |                 |
| Medical                    | 325 (51.3)       | 349 (45.1)   | 124 (31.3)     | 49 (39.2)     | 26 (17.2)       |
| Non-Medical                | 309 (48.7)       | 424 (54.9)   | 272 (68.7)     | 76 (60.8)     | 125 (82.8)      |
| Total                      | 634 (100)        | 773 (100)    | 396 (100)      | 125 (100)     | 151 (100)       |
| Gender                     |                  |              |                |               |                 |
| Male                       | 181 (28.5)       | 244 (31.6)   | 91 (23.0)      | 24 (19.2)     | 51 (33.8)       |
| Female                     | 453 (71.5)       | 529 (68.4)   | 303 (76.5)     | 101 (80.8)    | 99 (66.6)       |
| Prefer not to say          |                  |              |                |               | 1 (0.7)         |
| Total                      | 634 (100)        | 773 (100)    | 396 (100)      | 125 (100)     | 151 (100)       |
| Age range                  |                  |              |                |               |                 |
| 18–20                      | 121 (19.1)       | 208 (26.9)   | 90 (22.7)      | 7 (5.6)       | 44 (29.1)       |
| 21–24                      | 305 (48.1)       | 375 (48.5)   | 231 (58.3)     | 46 (36.8)     | 69 (45.7)       |
| 25+                        | 208 (32.8)       | 190 (24.6)   | 75 (18.9)      | 72 (57.6)     | 38 (25.2)       |
| Total                      | 634 (100)        | 773 (100)    | 396 (100)      | 125 (100)     | 151 (100)       |
tending to be more positive in the face-to-face meetings than the online survey. There was a significant association between the intent to vaccinate and vaccination knowledge and attitude scores, and with HCP or public health websites as the data source (Figure 2).

Discussion

We collected detailed data on the knowledge, attitudes, and behaviors toward vaccinations among a sample of university students, and linked these results to action on vaccination. Our results indicate that knowledge about vaccines was high among the student respondents, and that the majority held positive attitudes to vaccination and considered them to be safe and effective. High levels of knowledge, positive attitudes, and confidence in vaccines were positively associated with age, higher level of study, being a medical student, a recent vaccination experience, and not knowing trusted persons who did not believe in vaccines. These results are consistent with other

| Variables          | Plan to receive a next vaccine | No idea/no intent to receive next vaccination |
|--------------------|-------------------------------|---------------------------------------------|
| Period since last  | n (%)                         | n (%)                                       |
| vaccination        |                               |                                             |
| Within last year   | 399 (37.9)                    | 235 (23.0)                                  |
| <5 years           | 371 (35.1)                    | 402 (39.3)                                  |
| 5–10 years         | 174 (16.5)                    | 222 (21.7)                                  |
| >10 years          | 62 (5.9)                      | 63 (6.2)                                    |
| Can't remember     | 50 (4.7)                      | 101 (9.9)                                   |
| Total              | 1056 (100)                    | 1023 (100)                                  |
| Gender             |                               |                                             |
| Male               | 255 (24.1)                    | 336 (32.8)                                  |
| Female             | 801 (75.9)                    | 684 (66.9)                                  |
| Prefer not to say  | -                             | 3 (0.3)                                     |
| Total              | 1056 (100)                    | 1023 (100)                                  |
| Faculty            |                               |                                             |
| Medical            | 593 (56.2)                    | 280 (27.4)                                  |
| Non-Medical        | 463 (43.8)                    | 743 (72.6)                                  |
| Total              | 1056 (100)                    | 1023 (100)                                  |
| Country            |                               |                                             |
| Italy              | 792 (75.0)                    | 521 (50.9)                                  |
| Belgium            | 264 (25.0)                    | 502 (49.1)                                  |
| Total              | 1056 (100)                    | 1023 (100)                                  |

Figure 1. Principal component analysis. Results of principal component analysis reveals correlation of intent to vaccinate (Vxplan) as outcome variable with primary components measured in the survey. A positive correlation is observed with variables representing education (knowledge, school, courses) on the left side of the figure. There is also an association of intent of vaccinate with the group of parameters related to local culture (country, family and lifestyle).
studies that have demonstrated higher confidence in vaccines among medical students,\textsuperscript{3,9} the positive influenza of past vaccine administration on the intention to receive future vaccinations,\textsuperscript{19,23} and the negative influence of trusted persons who hold negative opinions about vaccination.\textsuperscript{7,9}

Uniquely, we assessed the intent to vaccinate among university students by constructing a dependent variable (planned vaccination) based on whether students knew when their next vaccination was due, or if they knew what their next vaccination should be. As might be expected, the intent to vaccinate was correlated with vaccine knowledge, attitudes, and being a medical student. However, age, female gender, and using public health websites and HCPs as sources of information about vaccines were also correlated with intent to vaccinate. The self-reported role of social media as a source of information was low. We observed that industry-sponsored vaccine awareness was not perceived overly negatively, and a generally strong willingness of students to learn more about vaccines recommended for them.

Country of origin was highly correlated with the survey responses and was clustered with lifestyle, family, and data source variables, suggesting a strong modifying effect of culture and family attitudes on how vaccines are perceived in this age-group. In the region of Tuscany where the University of Pisa is located, there was an increase in meningococcal meningitis cases including cases in young adults, with some deaths, which prompted distribution of free meningococcal vaccine in 2017 for all university students.\textsuperscript{26} Additionally, from 2017 the Italian government adopted measures to enforce a legal obligation on parents to vaccinate their children.\textsuperscript{27} As a result of the ensuing public debate, vaccinations were the focus of media attention in Italy for several months. The vaccine intervention and public discussion explain why most of the students who had received a vaccine within the last year were from the Italian university, and could have contributed to differences in

| Variable       | Estimate | Standard error | Z value | Pr (z) |
|----------------|----------|----------------|---------|--------|
| (Intercept)    | 0.0196   | 0.1316         | 0.15    | 0.8815 |
| PC1            | 0.2505   | 0.0352         | 7.11    | 0.0000 |
| PC2            | 0.0950   | 0.0525         | 1.81    | 0.0705 |
| PC3            | −0.0662  | 0.0486         | −1.32   | 0.1864 |
| Data source    | −0.4238  | 0.2254         | −1.88   | 0.0601 |
| Country        | −0.3441  | 0.2274         | −1.51   | 0.1303 |
| Gender         | −0.4643  | 0.1222         | −3.80   | 0.0001 |
| Age            | 0.3187   | 0.0848         | 3.76    | 0.0002 |

Primary Component Analysis shows that intent to vaccinate is significantly associated to Age, gender, and Country (PC1, the most important factor). PC1 is furthermore correlated with a number of lifestyle factors. The composed influence of these factors underlines the role of environment plays in vaccine confidence.

Figure 2. PCA loadings used for the PCA regression (excluding demographic variables). PCA regression showed that variability of primary component 1 was mainly associated with knowledge about vaccination.
vaccine knowledge, attitude, confidence, and intent to vaccinate observed between the respondents from the Italian university and the Belgian university.23 Promotion of vaccination by the Belgian government has, on the other hand, been systematic, but without such major spikes in public debate, perhaps except for the occasional measles outbreak in the years before the study. Positive associations between vaccine knowledge and attitudes to vaccination have been shown previously in other studies.24,25,28

We observed that vaccine knowledge, attitudes, and confidence, as well as the intent to vaccinate, were all influenced by age, with higher scores in older students, even though the age-groups studied were narrow (18–20, 21–24, and ≥25 years). The effect of age on vaccine attitudes appears to be conflicting, with some studies reporting improved confidence with increasing age while other suggesting the reverse.24,25 Medical students receive training in vaccinology later rather than earlier in their course, and in our study older respondents in Italy may be more likely to have been involved in the meningococcal public health campaign the year prior to the survey. Both factors could have contributed to the observed association between age and vaccine knowledge, attitudes, and confidence.

Our study is potentially limited by an over-representation of female respondents, in whom vaccine confidence has been reported to be higher than males,20 and the potential for response bias toward students more interested in this subject who might be more motivated to complete an on-line survey. The study was performed at one university in Belgium, where medical students undergo a specific vaccinology module in their third year, and Italy, which may not be representative of the entire student population in both countries. Finally, we observed a general trend of more positive responses among participants in face-to-face interviews than in online surveys, although the small number of students who participated in face-to-face interviews precludes further analysis.

In conclusion, we found that vaccination attitudes and behaviors among students at University of Pisa, Italy and those of University of Antwerp, Belgium are positive. Only around one-half of respondents were aware of their next vaccination or displayed an intent to vaccinate, showing an ongoing need for vaccine education in this age-group. We show that the intent to vaccinate is correlated with two main clusters of variables linked to culture (country, family, lifestyle), and to scholarship (knowledge, attitudes, data source) that together influence the behavior of students with respect to vaccination. Our study reinforces previous findings that knowledge about vaccines is key to shaping attitudes and behaviors, but also shows that cultural and lifestyle factors as well as peer networks are another platform that could be leveraged in promoting vaccination among young people.

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Author contributions

All authors had full access to all the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis. All authors participated in the development of this manuscript, reviewed, and approved the final manuscript.

Disclosure of potential conflicts of interest

IV, AP, and AC are employed by GSK group of companies and do not have any non-financial relationships and activities to declare. IV also hold shares in the GSK group of companies.

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