Predictors of Meningococcal Vaccine Uptake in University and College Students: A Systematic Review and Meta-Analysis

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**ABSTRACT**

**Objective**

To identify predictors of meningococcal vaccine uptake among university and college students, the most common carriers of meningococcal disease.

**Participants**

University or college students aged 18 to 25 years.

**Methods**

Multiple databases, citations, and grey literature were systematically searched in April 2017 and January 2019, for articles reporting rates and predictors of vaccine uptake. Included studies underwent quality appraisal, and, where suitable, meta-analyses were performed.

**Results**

Twenty-one articles, covering 18 studies from six countries, were included. They were mostly cross-sectional surveys of routine vaccination. Meta-analyses were conducted on six predictors. Higher vaccination uptake was associated with being a first year student, an undergraduate student, not being an international student, perceiving meningococcal disease as a risk, and being female.

**Conclusion**

Identified key predictors correspond with previous studies and other vaccines. The findings should inform the delivery and communication of meningococcal vaccination to university and college students.

Keywords: meningitis; university; meta-analysis; vaccination; students

**Introduction**

Meningococcal disease (MD) is a rare but serious disease most often associated with people living in the African “meningitis belt”, although it also occurs worldwide. *Neisseria meningitidis*, its causal bacterium, is a gram-negative diplococcus bacteria, spread through respiratory secretions during close or lengthy contact, with a usual incubation period of 2-10 days1,2. There are 12 serogroups of *N. meningitidis*, with six (A, B, C, W-135, X, and Y) having the highest incidence3. A variety of licensed vaccines are available (Table 1) with the type used dependent on the situation, population, serogroup, length of desired protection, as well as vaccine availability by country, which is highly dependent upon serogroup endemicity, and affordability4.

While MD usually results in asymptomatic carriage, it sometimes invades the body, leading to invasive meningococcal disease (IMD)18. Annual global incidence of IMD is around 1.2 million, resulting in approximately 135,000 deaths, with burden varying by region19. The CDC20 reports a U.S. incidence rate of 0.11 per 100,000 for 2017, while the ECDC18 reported an incidence of 0.6 per 100,000 for Europe in 2016, and incident rates of disease are known to vary from 20 to 1,000 per 100,000 in Africa21. Children younger than one year have the highest incidence, while adolescents and young adults have the highest carriage, and the second highest incidence22.

Because close or lengthy contact is necessary for developing MD, frequenting bars, smoking or smoke exposure, kissing, and having a small, crowded living space, which may be typical of a university or college student’s lifestyle, are important risk factors23,24. Within the past twenty years, public health authorities have reported a sharp increase in meningitis incidence in university and college students, with many age-relevant vaccination schedules now including the meningococcal vaccines, and some countries undertaking vaccination campaigns. Despite these efforts, many students remain unvaccinated 25–27.

***Health and economic burden***

Diagnosing IMD quickly and accurately is important as its onset can be insidious, but it is often mistaken for more common, less serious illnesses28. Its most common clinical presentations include bacteremia (30% of cases), bacteremic pneumonia (15% of cases), and meningitis (50% of cases)28,29. A subset of bacteremia cases present as meningococcemia, the most dangerous manifestation as patients often fail to respond to treatment, and can die within hours of disease onset28,30. While IMD has a case-fatality rate of 8-15%, meningococcemia itself has a case-fatality rate of up to 40%, with up to 20% of meningococcemia survivors experiencing sequelae such as amputation or neurological and hearing impairment18. A recent systematic review by Olbrich et al.31 found that IMD survivors without physical sequelae faced both short- and long-term negative impacts on self-esteem, physical, and mental health including anxiety, learning difficulties, and emotional and behavioural difficulties. These impacts were worse in survivors with physical sequelae.

Although the disease is rare, hospital admission may contribute to a considerable economic burden, including high indirect economic costs32,33. In 2013 the average cost of outbreak containment in high income countries was reported as almost $600,000 with the cost per IMD case being more than $55,000.34

***Context of vaccination***

The context of vaccination is important to consider when assessing factors of uptake as this may change the strategies used for reaching and educating target groups, and may inform officials directing vaccination activity. There are three main contexts to consider:

Routine: This is the most common public health use. An example is the meningococcal C (MenC) vaccines being part of the immunization schedule for infants and young children in the U.K., U.S.A. and Canada35–37.

Campaign: Campaigns may be held in conjunction with routine use, often targeting a specific age group after immunization schedules have been changed, or aiming to extend protection to a group that is disease-vulnerable, but which does not fall under the standard immunization schedule. For example, the U.K. implemented a catch-up campaign for adolescents and first-time university and college students aged up to 25 years, following the introduction of routine school meningococcal ACWY (MenACWY) immunization in 15-year-olds38.

Outbreak: An outbreak is defined as two or more confirmed or probable cases that have a common link, have occurred within four weeks of each other, and are from the same strain35. Close contacts of confirmed cases are given chemoprophylaxis to eliminate any established disease carriage and reduce risk of transmission35. Vaccination is also often given to reduce long-term disease risk of disease in outbreaks where case(s) are caused by vaccine-preventable strains35.

***Vaccination policies***

The first mandatory meningococcal vaccinations occurred in the U.S.A. in 1971, prior to the vaccine’s licensing for the general public in 1974, to address the ongoing epidemic in new military recruits due to wartime mobilization39,2,40. Recommendations for U.S. college students to be vaccinated followed shortly after in 199841. When the U.K. introduced routine vaccination for infants in 1999, they included a catch-up programme for 18 year olds, later extended to those aged up to 2539. In 2005 the U.S. CDC Advisory Committee on Immunization Practices expanded recommendations to cover all undergraduates under 25 and other students with immunocompromising conditions39. Other large-scale immunization campaigns have occurred in Quebec, Canada (1993) and Catalonia, Spain (1997)39.

Sharp increases in IMD incidence25–27, disease severity and its associated costs, and relatively low levels of vaccine uptake, all indicate the need for research to understand predictors of vaccination rates in university and college students. Furthermore, despite many universities requiring meningococcal vaccination, Castel et al.42 found that only two U.S. universities (7% of the population sampled) were compliant with all components of the law mandating vaccination. A better understanding of factors involved in the uptake of meningococcal vaccination in this population may help to improve coverage.

As such, to help inform practice and policy, as well as highlight any gaps in knowledge, the aim of this systematic review is to provide aggregated information on rates of meningococcal vaccination in university and college students, and its predictors. No previous relevant systematic reviews have been identified.

**Method**

***Search strategy***

Three databases, Medline (Epub ahead of print, in-process other non-indexed citations, Ovid Medline daily and Ovid Medline 1946 to present), Embase, and CINAHL were initially searched in April 2017, and updated in January 2019. The search strategy utilised Boolean operators, free text, truncation, and MeSH terms (see Appendix 1). Backwards and forwards citation searches were conducted on included articles to identify additional studies. We used Medline for grey literature searching, with further searching being conducted using White Rose Research Online, Ethos British Library, and ProQuest by using a simplified search strategy of meningococcal vaccines and university students. The search strategy was developed, piloted, and implemented, using an Excel spreadsheet to record all identified studies.

***Study Eligibility***

The search was limited to papers published in English after 1974, when the first meningococcal vaccine was licensed2. Studies needed to focus on university or college students (undergraduate and/or postgraduate), with the primary focus on students aged 18-25 years. Studies of any meningococcal vaccine could be included but needed to report uptake rates and include data on demographics and unvaccinated students. Modelling studies, cost-effectiveness analyses and opinion pieces were excluded (Appendix 2).

***Study selection and data extraction***

Two reviewers independently screened papers first by title, abstract (JW and JMK), and then full text (JW and PK). Discrepancies were resolved by consensus. Reasons for exclusion at the full paper screening stages were recorded. Endnote version X8.0.043 was used to remove duplicates.

Data extraction was completed by one reviewer (JW), and independently reviewed by another for accuracy. Extracted variables were: year of publication, setting, why vaccination was conducted (vaccination implementation, outbreak response, etc.), study design, number of participants vaccinated and not vaccinated, details of each group (age range, gender, year of study, etc.), and any reported evaluative or attitudinal variables (e.g. stated reasons for vaccination or not, risk perception, etc.). Some studies included other information such as health behaviours (smoking, exercise, etc.), if participants received other vaccinations (e.g. against flu), or reasons/ influences on vaccination; these were also extracted.

***Critical appraisal of included studies***

Included studies were appraised for potential bias using the relevant tools from the Joanna Briggs Institute (JBI) for cohort, case-control and cross-sectional studies44 (Appendix 3).

As recommended 45, studies of low methodological quality were no excluded because on balance we thought it more important to maximize the size of the relatively small evidence base. Sensitivity analyses based on study quality, were not undertaken.

***Data analysis***

When three or more studies provided odds ratios or risk ratios, and 95% confidence intervals (or data from which they could be calculated), a random effects meta-analysis of predictor variables was undertaken by vaccination context (routine, campaign, or outbreak). Variables not eligible for meta-analysis were reported descriptively. Heterogeneity among studies was explored using statistical tools. Where possible, analyses were also carried out on additional variables, such as factors influencing vaccination uptake or refusal.

Statistical testing and meta-analyses was undertaken using Review Manager 5.346.

The systematic review protocol was registered (PROSPERO CRD42017060642) and can be accessed at http://www.crd.york.ac.uk/PROSPERO/display\_record.asp?ID=CRD42017060642. Post-protocol registration, search criteria were updated to include studies from 1974 onwards, to reflect the correct date when the first meningococcal vaccine was licensed. Full paper screening was done by two instead of three researchers due to feasibility, although all three participated in discussions when discrepancies arose. Finally, the risk of bias tool was changed to the JBI critical appraisal tools as it has quality appraisal tools for all three included study types (cohort, case-control, and cross-sectional), rather than just one or two. This allowed for greater comparability between study types.

**Results**

***Results of the database searches***

Initial database searches conducted in April 2017 resulted in 3,073 records (2,726 from databases, 347 from grey literature searching) with the January 2019 search adding a further 1,858 records. Following screening and full paper assessment, twenty-one full papers were included (covering 18 studies), on which forwards and backwards citation searching was undertaken (Figure 1).

***Excluded studies***

Other than papers excluded during screening, two papers were excluded as full texts because they were not obtainable, and six papers were excluded during data extraction due to unsuitable outcome variables.

***Included studies***

Seven of the eighteen included studies had an outbreak context, eight had a routine context, and two were in the context of campaigns. In terms of study design:

* 12 studies were cross-sectional, reported in single articles;
* One study was cross-sectional, covered by two articles47,48;
* Two studies were cohort studies49,50;
* One study included both cohort and nested case-control elements51;
* Two studies were covered by two articles52–55 each, including both cohort and cross-sectional elements.

Details of included studies and vaccination rates are reported in Tables 2 and 3.

***Summary of studies***

*Demographic characteristics*

Included studies were published 1996-2018, with eight being U.S. based, six U.K. based, and one each from Canada, Taiwan, India and Germany. Four studies did not report the vaccine used, and one was unclear. Four studies did not report education level of the student participants and five did not report participant gender, although overall females largely outnumbered males. Most studies included all undergraduates from all degree years, with six studies including only first year students, and five including both undergraduate and graduate students.

Eight studies reported the percent of subjects who responded to the study questionnaire (ranging from 6.8% to 100%), while sample sizes ranged from 420 to more than 39,000 participants. One study62 reported intentions to vaccinate and not actual vaccination uptake. Most studies reported overall vaccination uptake rates as greater than 50% (Table 3). Variables of interest for the review were not reported in every study.

*Challenges with included studies*

In Langley et al.48, two separate surveys were conducted after each of the first two vaccination doses. All students (vaccinated and unvaccinated) were eligible to participate. However, as the authors did not differentiate between students who were repeat participants and those who were new, we only included overall vaccination data and the demographics from the survey responses following dose one.

For MacDougall et al.47, although the authors did not separate faculty and staff data from student data, the proportion of the total sample eligible to receive the vaccine that were faculty and staff was low (9.2%). As it was determined that they would not significantly influence the results, the study was included.

As the study by Roberts et al.51 included both cohort and nested case-control elements, objective data (Table 4) were extracted from the cohort study, and subjective data from the nested case-control study.

For studies reported in multiple papers, the source of the included data is indicated in the tables.

*Quality assessment*

Study quality assessment is reported in Table 5. For the fifteen cross-sectional studies, scores ranged from 3 to 7 (out of a maximum of 7), with a mean score of 6. The five cohort studies ranged from 6 to 9 (mean 8) (out of a maximum of 9), and the single case-control scored 8 out of 8. Sensitivity analyses based on study quality were not undertaken due to the small number of studies included in the meta-analysis for any predictor, and because most studies rated on the higher end (6 and above) of possible quality assessment scores (Table 5).

***Meta-analysis***

Meta-analyses were undertaken to assess vaccine uptake by gender, student education level (first years vs other undergraduates, and undergraduates vs postgraduates), ethnicity, students’ origins, and perceived risk and severity of MD by context. Variables not meeting the minimum number of studies (three) for meta-analysis inclusion have been described descriptively. Many meta-analyses undertaken could only be done for one or two of the contexts due to an insufficient number of studies with matching data. No analyses could be undertaken for the campaign context as there were only two included studies. Variable context has been indicated in the variable header.

*Gender- routine and outbreak*

In the gender analysis for routine vaccination (Figure 2), females had a lower odds of vaccinating than males (OR 0.55; 95% CI 0.20 – 1.56), whereas the opposite was the case for the outbreak analysis (OR 1.18; 95% CI 1.07 - 1.31) (Figure 3). The differences seen could be due to differences in the volume of available data for analyses (outbreak having six while routine only had three) or could indicate that females are indeed more likely to uptake during an outbreak setting. In all of the included routine studies, and all but one of the included outbreak studies, females largely outnumbered males, which could indicate greater female willingness to respond to surveys.

*Student education level- outbreak*

In an outbreak setting, first year students were more likely than undergraduates from other years, to be vaccinated (OR 1.94; 95% CI 1.65 - 2.27) (Figure 4). Undergraduates also had higher odds of being vaccinated than postgraduate students (OR 6.07; 95% CI 4.47 - 8.23) (Figure 5). However, as we were not able to undertake a multivariate analysis to control for potential confounding factors, these results should be interpreted cautiously.

*Ethnicity- outbreak*

The overall odds of students of white ethnicity vaccinating during an outbreak were 1.25 (95% CI 1.01 - 1.56) that of students of other ethnicities, derived from four U.S. studies (Figure 6) which included much larger numbers of students of white ethnicity than of other ethnic groups. This could indicate that, in outbreak settings, the methods used to inform students are failing to reach parts of the student population.

*Students’ origins- routine*

For students attending U.K. universities, the odds of U.K. nationals vaccinating were 4.94 that of international (non-U.K.) students (95% CI 3.76 - 6.49) (Figure 7). This could largely be reflecting the differences in immunization schedules between the U.K. and international students’ home countries; equally U.K. universities may be missing opportunities to inform incoming international students.

*Perceived risk and severity of MD- outbreak*

Students who felt at risk of contracting meningococcal disease had a 3.23 (95% CI 0.89 - 11.7) greater odds of vaccinating than students who did not feel at risk (Figure 8), while students who perceived MD to be severe had 1.80 (95% CI 0.73 - 4.44) greater odds of vaccinating than students who did not perceive it as severe (Figure 9).

***Other predictor variables not included in meta-analyses***

Of the eighteen studies included, only a subset could be used in meta-analyses. Studies that could not be included by context: two outbreak studies58,68, both campaign studies49,59, and five routine studies60–63,67. For some of these studies, data was not reported in a way that allowed for meaningful extraction, and in others data could be extracted but there were not enough studies to meet the three-study minimum for meta-analysis. These studies and relevant predictor variables are described below.

*Pre-university vaccination*

Three U.K. studies included vaccination rates for incoming first year students. Edmunds et al.59 found that 51% of U.K.-based students were vaccinated prior to arrival, compared to 3.8% of international students. Turner et al.49 reported that overall 31% of students were vaccinated prior to arrival, of which only 1% of international students had been vaccinated. Moore et al.69 reported that 49.6% of students were vaccinated at arrival, including 71.5% of U.K. nationals and 33.7% of international students.

*Intentions to be vaccinated*

Two papers provided data on intentions to vaccinate. Huang et al.62 on Taiwanese students planning to study in the U.S., found that 91.3% of respondents intended to be vaccinated. By comparison MacDougall et al.47 found that only 0.6% of unvaccinated students in Canada intended to receive the first dose of MenB, whereas 64.3% of students already vaccinated with one dose intended to receive the second dose.

*Other vaccinations*

Few studies reported on students’ other vaccination habits. Those that did were inconsistent regarding vaccines covered or how the data was presented, making pooling difficult. In D’Heilly et al.61 students immunized against MMR (measles, mumps, and rubella) and DT (diphtheria and tetanus) had a higher odds of receiving meningococcal vaccinations (OR 2.79; 95% CI 2.25 - 3.46), and there were similar positive associations between meningococcal vaccination and hepatitis B vaccination (OR 3.39; 95% CI 2.86 - 4.01) and influenza (flu) vaccination (OR 2.81; 95% CI 2.44 - 3.23). A similar trend of meningococcal vaccination and flu vaccination was seen in a routine vaccination setting57 (OR 3.91; 95% CI 2.94 - 5.20).

*Knowledge of meningococcal disease*

Two studies reported aspects of student knowledge regarding MD. Thirlaway and Lukman60 surveyed knowledge of different aspects of MD (different forms, symptoms, disease consequences, and groups at risk) based on literature released by the National Meningitis Trust. Vaccinated students had a mean overall MD knowledge score of 7.06 (SD 2.74) compared to unvaccinated students (mean score 6.10; SD 2.78), although the highest possible score was 21 suggesting that levels of knowledge were not high in either group. Vaccinated students were more likely (69.3%) than unvaccinated students (56.5%) to know about the effectiveness of the MenC vaccine.

MacDougall et al.47 used a modified version of a previously validated survey70 and found that vaccinated students were more likely to know what meningitis is, and its transmission mode. However, neither difference was statistically significant (OR 1.40; 0.43 - 3.95) and (OR 3.38; 0.57 - 13.9), respectively.

*Influence of parents, doctors and peers*

For outbreak studies reporting the effect of parental influence on meningococcal vaccination uptake, Breakwell et al.57 found that 71% of vaccinated students reported this as a contributing factor to their uptake, including 16% that reported it as the most influential reason. Similarly, Fisher et al.55 found that 56% of vaccinated students reported their parents asking them to get vaccinated being the most important reason contributing to their decision to uptake. MacDougall et al.47 found that students who reported their parents having a significant influence on their decision had 5.35 greater odds of vaccinating (95% CI 1.54 - 21.2).

Regarding peer influence on vaccination uptake, MacDougall et al.47 found that those who reported they would vaccinate if their friends thought vaccination was important had a 12.8 higher odds (95% CI 3.79 - 50.1) of reporting an intention to uptake, and 9.05 greater odds (95% CI 2.95 - 29.8) of being vaccinated. Similarly, 66% of vaccinated students in Breakwell et al.57 reported their friends telling them to get vaccinated as being a contributing reason to their vaccination uptake. Conversely, students who reported no peer pressure regarding vaccination in Roberts et al.51 were 5.70 times (95% CI 3.90 - 8.40) more likely to not vaccinate. It is particularly important to note that peer influence is likely to be more important in outbreaks than in other settings.

Finally, in looking at the influence healthcare professionals hold over vaccination uptake, Breakwell et al.57 found that only 23% of vaccinated students reported that their doctor advised them to get vaccinated. MacDougall et al.47 found in univariate analysis that students who reported that they would uptake the vaccine if their health care professional thinks it is important, were 15.41 times (95% CI 4.45 - 53.4) more likely to intend to uptake vaccination, and 12.8 times (95% CI 3.80 - 42.4) more likely to be vaccinated.

**Discussion**

***Key findings***

The review identified 21 papers that reported 18 studies examining the rates of MD vaccination among university and college students, and the effects of demographic and other variables on vaccination uptake. Student’s year of study (first years vs other undergraduates, and undergraduate vs postgraduate), students’ origins, and perceived risk of contracting MD all had strong positive effects on a student’s decision to receive MD vaccination. Students’ gender, ethnicity, and perceived severity of MD were moderate influences.

***Quality of Evidence***

*Strengths of the current review*

Included studies in this review were from six countries, allowing for a more international view. Studies were mostly rated on the higher end of possible quality assessment scores and covered a wide range of predictors, with moderate overlap between studies, allowing for data pooling. Although most of the studies did not report a sample size calculation, sample sizes ranged from 420-39,307, with the majority being over 2,000 (Table 2).

The review applied explicit inclusion and exclusion criteria and the thorough searching of multiple databases, including forwards and backwards citation searching, with a comprehensive search strategy. All included studies underwent quality appraisal using verified tools, ensuring all study types were treated comparably. All screening and extraction was performed independently by two reviewers, or independently checked to ensure accuracy.

*Limitations of the current review*

Most of the study data were reported in a way that did not allow inclusion within the meta-analysis. Many papers did not include absolute numbers for every variable, or only reported grouped data. Often when vaccination numbers and other demographics were given, they were not reported so as to allow calculation of the proportion of students in each demographic group that were vaccinated. Although a majority of the studies scored well (six and above) on quality appraisal, most studies scored poorly on vaccination uptake being self-reported, response rates, handling possible confounding variables or sampling method. Notably several lower quality studies (scores under six) had problems with a variety of methodological points. It is worth noting that while many of the surveys either recorded vaccination data as they were being administered or linked health records to verify vaccination status, a few surveys relied solely upon respondents’ knowledge of their vaccination history. As such, including these surveys into our analyses may have introduced response bias. Survey response rates ranged from very low (6.8%) to complete (100%), with studies mostly falling at one end of the spectrum or the other with little in-between. Many studies struggled with survey non-response despite efforts to increase response. Some studies limited their study sample, making the sample not representative of a typical university or college population.

Although all screening and data extraction were carried out by two reviewers, due to time limitations all critical appraisals were undertaken by a single reviewer. This could have introduced error but its importance is reduced because study quality was not used as an entry criterion or within sensitivity analyses. Due to resources constraints we limited the review to only papers published in English which may mean that some relevant studies were not included. The included studies were sourced from only six countries, which could reflect the true range of undertaken studies, or could be due to our English language restriction or because immunization schedules in other countries predominately target populations other than university and college students.

Some of the reported meta-analyses had high levels of statistical heterogeneity (indicated by the I2 statistic). While a higher level of I2 may be a function of a small number of included studies in meta-analyses, as is the case for many of the analyses reported here, point estimates derived from highly heterogeneous meta-analyses should be viewed cautiously. Furthermore, it is likely that the effects of some variables are confounded, such as education level and living arrangements, since many universities require first year students to reside in student housing71; indicating a need for primary studies to report multivariate analyses or to make their datasets available for individual participant data (IPD) analyses. Efforts were made during initial stages of the review to acquire further data on included studies as required, but with limited success.

There is relatively little evidence to test the predictive effect of some variables on vaccination uptake. Many studies reported rates of vaccination but either did not collect or report the key data that was needed for meta-analyses. For some of the meta-analyses, exact odds ratios and confidence intervals extracted from the primary studies could not be included, as noted within the figures. Often this was because the original data had been adjusted to account for other variables. Furthermore, the included studies were mostly cross-sectional, which are not able to establish causal relationships72.

Of the three contexts in which meningococcal vaccines are used (routine, campaigns, outbreaks) evidence for immunization campaigns was relatively lacking as only two of the included studies focused on this.

*What this systematic review adds*

To our knowledge this is the first review looking at predictors of meningococcal vaccine uptake in university and college students and one of the first reviews looking at predictors of vaccination uptake within a meta-analysis. Furthermore, by splitting our analyses by vaccination context we are able to identify any potential differences among predictors.

Predictors of uptake for other vaccines may highlight potential MD vaccination predictors. The opinion of the doctor has been found to be influential for Human Papilloma Virus (HPV) vaccine uptake(16,52,53), and influenza vaccine uptake(54). Although no reviews looking at predictors of influenza vaccines are available, Uddin et al.(54) also found vaccination status for the prior flu season to be important, while Benjamin and Bahr(55) found a student’s perceived low risk of contracting influenza to be a barrier to vaccination. Vaccination status in these studies was self-reported, which may influence reported rates.

The importance of ethnicity(52) has previously been noted, supporting the findings of this review. Socioeconomic status(54) has also been noted, however socioeconomic status could not be assessed in this review due to lack of data. For studies conducted in countries without universal health coverage, cost as a barrier to vaccination could not be assessed due to lack of data, although this is reported to be an important barrier in the uptake of other immunizations(53,55).

Observed effects of first year undergraduates being more likely to vaccinate than other undergraduate students could be attributed to first years being more likely to live on campus, potentially engaging in health services more recently or being more swayed by parental influence. As a result, they could be more likely to uptake information regarding vaccination clinics or find convenient on-campus vaccination clinics than those who live off campus.

While the aspects of MD covered by the studies assessing disease knowledge are important for those working in healthcare, it may be unrealistic to expect university and college students to have more than basic knowledge about symptoms, risk factors and vaccination.

***Recommendations***

*For practice*

Based on results of this review, the recommendations of peers, health care professionals and parents played an important role in students’ vaccination decisions. Thus, future immunization campaigns should consider taking advantage of these influential relationships.

As highlighted by this review and others, health care professionals could help minimize missed vaccination opportunities by discussing MD vaccination with all adolescent and young adult patients. This further extends to on-campus health facilities as international students were identified as having very low rates of uptake. University and college health clinics should make efforts to actively offer vaccination to students as immunization practices and schedules vary by country.

This review found that first year students were more likely to be vaccinated than other undergraduates. University and college vaccination policy efforts may therefore be best focused towards targeting undergraduates during their first year. This also indicates that undergraduates other than first years, as well as international and postgraduate students, who were also identified as having low vaccination rates, will require increased efforts to encourage vaccination uptake. In particular, future outbreak management schemes should recognize that peer influence, and the increased perceived risk of MD that most students feel in these situations, can increase MD vaccination uptake.

*For research*

Future vaccination uptake research should be reported more clearly. In particular, demographic and predictor variables should report absolute vaccination numbers, and the grouping of data, especially by age, should be avoided. Of the few studies that assessed students’ attitudes towards vaccination, little consistency was observed between studies regarding questions asked, making data pooling difficult. Furthermore, few studies looked into risk factors, knowledge, other vaccination habits, or attitudes, which could prove insightful for future practice.

**Conclusion**

Key predictor variables of vaccination uptake included being a first year student (versus other undergraduates), an undergraduate student (versus postgraduate), originating from the U.K. (compared to international students), and being female. However, shortcomings in data reporting limited the analyses. Furthermore, some potentially important factors, such as perceived risk, knowledge of meningococcal disease, and previous vaccinations, were not explored in all studies. Universities, colleges, and health care professionals could emphasize MD severity to incoming students, particularly in countries where vaccination is not compulsory for higher education attendance or not part of the routine immunizations for adolescents and young adults.

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**Declaration of Interests**

None.

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**Appendices**

Appendix 1. Search strategy for Medline (Epub ahead of print, in-process other non-indexed citations, Ovid Medline daily and Ovid Medline 1946 to present), Embase, and CINAHL.

1. Neisseria meningitidis/
2. Neisseria meningitidis.mp.
3. 1 or 2
4. Meningococcal disease.mp.
5. Meningitis, meningococcal/
6. Meningococcal.mp.
7. Meningococcal infections/
8. 4 or 5 or 6 or 7
9. 3 or 8
10. Meningococcal vaccines/
11. Meningococcal vaccin\*.mp.
12. 10 or 11
13. Vaccines/ of Vaccination/
14. Disease Outbreaks/ or Mass Vaccination/
15. Vaccin\*.mp.
16. 13 or 14 or 15
17. Immunization Programs/ or Immunization/
18. Immuniz\*.mp.
19. 17 or 18
20. 12 or 16 or 19
21. Universities/
22. Universit\*.mp.
23. College.mp.
24. 21 or 22 or 23
25. Education/
26. Education.mp.
27. Health Promotion/
28. Health Promotion.mp.
29. 25 or 26 or 27 or 28
30. Further education.mp.
31. Higher education.mp.
32. 30 or 31
33. 24 or 29 or 32
34. University student\*.mp.
35. College student\*.mp.
36. Students/
37. Student\*.mp.
38. 34 or 35 or 36 or 37
39. Young adult/
40. Young adult\*.mp.
41. Young person.mp.
42. Young people.mp.
43. 39 or 40 or 41 or 42
44. 38 or 43
45. 33 or 44
46. 9 and 20 and 45

Appendix 2. Review inclusion and exclusion criteria.

|  |  |  |
| --- | --- | --- |
|  | Inclusion | Exclusion |
| Population | * University students * College students * Undergraduate students * Graduate students * Students aged >18 years * Primary focus should be on students aged 18-25 years | * Teenagers or adolescents * Adults * Young adults not in a form of higher education * Studies focusing on university or college faculty and staff * Studies focusing on students aged <18 years |
| Intervention | * Any meningococcal vaccine * Meningococcal disease outbreak management * Survey of prophylactic meningococcal vaccination uptake or intentions * Meningococcal vaccine campaign * Pre-university or college arrival vaccination | * Other vaccines besides meningococcal |
| Outcomes | * Vaccination uptake rates * Intentions to vaccinate * Objective data (age, gender, ethnicity, etc.) * Subjective data (influences to vaccination uptake) | * Studies without demographic data * Studies without uptake rates * Studies without unvaccinated student data |
| Study design | * Cross-sectional studies * Cohort studies * Nested case-control studies * Randomised Controlled Trials | * Modelling studies * Cost-effectiveness analyses * Opinion pieces |

Appendix 3. JBI critical appraisal tools [item 3 of Cross Sectional tool not used; items 2 and 3 of Cohort tool not used; items 4 and 5 of Case Control tool not used]

**JBI Critical Appraisal Checklist for Analytical Cross Sectional Studies**

Reviewer Date

Author Year Record Number

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Yes | No | Unclear | Not applicable |
| 1. Were the criteria for inclusion in the sample clearly defined? | □ | □ | □ | □ |
| 1. Were the study subjects and the setting described in detail? | □ | □ | □ | □ |
| 1. Was the exposure measured in a valid and reliable way? | □ | □ | □ | X |
| 1. Were objective, standard criteria used for measurement of the condition? | □ | □ | □ | □ |
| 1. Were confounding factors identified? | □ | □ | □ | □ |
| 1. Were strategies to deal with confounding factors stated? | □ | □ | □ | □ |
| 1. Were the outcomes measured in a valid and reliable way? | □ | □ | □ | □ |
| 1. Was appropriate statistical analysis used? | □ | □ | □ | □ |

Overall appraisal: Include □ Exclude □ Seek further info □

Comments (Including reason for exclusion)

**JBI Critical Appraisal Checklist for Cohort Studies**

Reviewer Date

Author Year Record Number

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Yes | No | Unclear | Not applicable |
| 1. Were the groups similar and recruited from the same population? | □ | □ | □ | □ |
| 2. Were the exposures measured similarly to assign people  to both exposed and unexposed groups? | □ | □ | □ | X |
| 3. Was the exposure measured in a valid and reliable way? | □ | □ | □ | X |
| 4. Were confounding factors identified? | □ | □ | □ | □ |
| 5. Were strategies to deal with confounding factors stated? | □ | □ | □ | □ |
| 6. Were the groups/participants free of the outcome at the start of the study (or at the moment of exposure)? | □ | □ | □ | □ |
| 7. Were the outcomes measured in a valid and reliable way? | □ | □ | □ | □ |
| 8. Was the follow up time reported and sufficient to belong enough for outcomes to occur? | □ | □ | □ | □ |
| 9. Was follow-up complete, and if not, were the reasons to loss to follow-up described and explored? | □ | □ | □ | □ |
| 10. Were strategies to address incomplete follow-up utilized? | □ | □ | □ | □ |
| 11. Was appropriate statistical analysis used? | □ | □ | □ | □ |

Overall appraisal: Include □ Exclude □ Seek further info □

Comments (Including reason for exclusion)

**JBI Critical Appraisal Checklist for Case Control Studies**

Reviewer Date

Author Year Record Number

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Yes | No | Unclear | Not applicable |
| 1. Were the groups comparable other than the presence of disease in cases or the absence of disease in controls? | □ | □ | □ | □ |
| 1. Were cases and controls matched appropriately? | □ | □ | □ | □ |
| 1. Were the same criteria used for identification of cases and controls? | □ | □ | □ | □ |
| 1. Was exposure measured in a standard, valid and reliable way? | □ | □ | □ | **X** |
| 1. Was exposure measured in the same way for cases and controls? | □ | □ | □ | **X** |
| 1. Were confounding factors identified? | □ | □ | □ | □ |
| 1. Were strategies to deal with confounding factors stated? | □ | □ | □ | □ |
| 1. Were outcomes assessed in a standard, valid and reliable way for cases? | □ | □ | □ | □ |
| 1. Was the exposure period of interest long enough to be meaningful? | □ | □ | □ | □ |
| 1. Was appropriate statistical analysis used? | □ | □ | □ | □ |

Overall appraisal: Include □ Exclude □ Seek further info □

Comments (Including reason for exclusion)