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Original article

Short Message Service Reminders to Parents for Increasing Adolescent Human Papillomavirus Vaccination Rates in a Secondary School Vaccine Program: A Randomized Control Trial

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A B S T R A C T

Purpose: In Victoria (Australia), the human papillomavirus (HPV) vaccine is delivered within a state-wide secondary school vaccine program, administered by local government. This study aimed to test the hypothesis that sending a short message service (SMS) reminder to parents who had consented to their child's receiving the HPV vaccine would lead to greater uptake of the vaccine within the program. The secondary aim was to assess the effect of self-regulatory versus motivational message content in the SMS.

Methods: A randomized control trial design was used across 31 schools within seven local government areas. Parents of 4,386 consented adolescents were randomized into three study conditions: motivational SMS versus self-regulatory SMS versus no SMS. Follow-up extended beyond the final school visit to the end of the calendar year to capture those who may have attended a catch-up vaccination session.

Results: On the day of the final school visit, 85.71% of consented students in the control condition received the HPV vaccine, compared with 88.35% (2.64% point increase) in the motivational message condition, and 89.00% (3.29% point increase) in the self-regulatory message condition, χ^2 (2, N = 4,386) = 8.31, $p = .016$. Both intervention messages were similarly effective at increasing vaccination rates. This effect was maintained in the extended follow-up period.

Conclusions: The trial findings supported the hypothesis that SMS reminders to parents/guardians would lead to greater uptake of the HPV vaccine in adolescents participating in school-based vaccination. Also, this effect was observed whether we used a motivational or self-regulatory message framework.

Trial registration: Australian New Zealand Clinical Trials Registry (ACTRN12617001307392). Registration Date: September 12, 2017. Retrospectively registered.

IMPLICATIONS AND CONTRIBUTION

Short message service reminders have shown to be effective at increasing vaccination rates in primary care settings. The current trial adds to this work by demonstrating their positive effect in a state-wide school-located vaccine program. Findings also provide the first assessment of testing different behaviorally informed message content on vaccination rates.

Conflicts of interest: This was a collaborative project where the funders (i.e., Public Sector Innovation – Department of Premier and Cabinet) were involved in the study design, decision to publish, and manuscript preparation.

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Protecting children from preventable diseases is a worldwide ambition as reflected by United Nations Sustainable Development Goal 3 (good health and well-being), which includes targets to end communicable diseases and to support research and development of vaccines [1]. This vision is shared by Australia through the activities of its local, state, and federal governments. To promote vaccination, both the federal Commonwealth Government and the Victorian State Government have relied on traditional regulatory approaches. The Commonwealth "No Jab, No Pay" policy cites that only parents of children (children aged <20 years) who are fully immunized in accordance with the National Immunisation Program schedule or are on a recognized catch-up schedule can receive certain child care benefits and rebates [2]. Similarly, Victoria's "No Jab, No Play" legislation requires children to be fully immunized for their age to be enrolled in an early childhood service [3].

Australia's National Immunisation Program schedule includes vaccines recommended for adolescents. One vaccine at the time of conducting the current research was the Gardasil quadrivalent, three-dose, human papillomavirus (HPV) vaccine (from 2018, this was revised to the Gardasil 9, two-dose schedule), which protects against genital warts and most cervical cancers [4]. In the state of Victoria, this federally funded vaccine is delivered by local government immunization providers (i.e., nurses based at local government office's), who visit local secondary schools three times per year to administer each dose of the vaccine to students enrolled in year 7 (and students aged 12–13 years in special education schools). This vaccine is also administered within primary care settings; however, most adolescents receive the vaccine through the school-based program. An estimated 76% of adolescents completed all three doses of the vaccine [5], and although this is comparable to other regions of Australia and to other countries that use a school-based program [6], it remained below the 80% target required for herd immunity [7].

Alongside regulatory approaches to optimizing vaccination rates, behavioral science offers additional strategies for policymakers to achieve their health goals, for example, parent reminders. A parent reminder is a letter, e-mail, card, phone call, or short message service (SMS) via mobile phone to parents/guardians of adolescents who are due or overdue to receive a vaccine [8]. This approach recognizes that the vast majority of parents are supportive of vaccination, and some parents fail to get their child vaccinated simply because they are unaware of the HPV vaccine schedule (i.e., unaware that their child is due to have the vaccine) or because they forget to book/attend a vaccination appointment with their health care provider [8]. Reminder strategies are especially important for adolescent populations who, compared with infants/children, have less contact with health care providers and are therefore less likely to be informed about the vaccine and to receive the vaccine opportunistically (i.e., when attending the clinic for other purposes) [8].

Reminders have been shown to be an effective intervention strategy for increasing adolescent vaccination rates within primary care settings in the U.S. [9–23] and have been championed by leading authority groups [24–26]. For example, Rand et al. [17] found that parent SMS reminders increased adolescent HPV (dose 1) vaccination rates in primary care settings by three percentage points (among parents with a valid phone number) and more recently found support for encouraging completion of the three-dose schedule [18]. However, vaccination delivery through school-based programs differs considerably from primary care settings and is arguably less susceptible to some of the barriers experienced in primary care settings. In Victoria's school-based program, a consent card and information booklet are sent home to all parents and returned to the school at the beginning of the year. Parents are also reminded about the vaccine session via the school newsletter/online parent portal in the weeks leading up to each school visit. On the day of vaccination, all year 7 students attend, and those students with consent are administered the vaccine, whereas students without consent wait for their class to be dismissed. Although not all students are at school on the day of vaccinations (an estimated 17% of year 7 students attend <90% of school days per year [27]), the vast majority are at school, and therefore, there may be less scope for improvement in the Victorian versus the U.S. primary care HPV vaccination setting.

The effect of reminders may also depend on the content of the message [28]. Research exploring the benefits of using implementation intentions—a self-regulation strategy proven effective across a variety of health contexts [29]—has shown that a simple request to "make a plan" for getting a flu shot increased vaccination rates within an organizational setting [30]. Another approach is to emphasize the individual's susceptibility to disease—a motivational strategy based on the Health Belief Model [31]—as an approach to increase motivation to perform protective behavior. One study revealed an increase in measles vaccinations by informing parents that children most at risk of measles are those that have not been immunized [32]. Together, both these behavioral techniques provide opportunity to increase the efficacy of reminders. However, neither of these strategies have been trialed on adolescent samples nor has their comparative effect been tested.

The primary aim of this study was to test the hypothesis that sending an SMS reminder to parents/guardians who had consented to their child receiving the HPV vaccine within the school-based program would lead to greater uptake (i.e., delivery) of the HPV vaccine within this program. The secondary aim was to assess whether the reminder message was more or less effective when incorporating a self-regulatory strategy compared with a motivational strategy.

Method

Ethics approval for this study was granted by the Monash University Human Research Ethics Committee (ref: 2016-7464-7293). This study involved a waiver of consent (parents/guardians and students) in accordance with 2.3.9 of the National Statement (Australia).

Recruitment

From the 77 local government immunization providers in Victoria, the research team identified 12 with a sufficient number of schools in their catchment to participate in the study. The Victorian Department of Health and Human Services then invited these providers to participate in the study on behalf of the research team. Seven providers, representing 108 schools, agreed to participate in the research. From these schools, the provider identified eligible schools to participate in the study according to the following criteria: (1) ≥20 students enrolled in year 7 to ensure the anonymity of the participating students, (2) the school had provided a class list with parental/guardian mobile

Table 1
Intervention message content

Intervention condition	SMS contents
Motivational SMS	Reminder from [name of provider]: [name of child] has a vaccine appointment at school this [day of week]. Vaccine preventable diseases are still a problem in the community and children most at risk are those that have not been immunised. Please contact xxxx xxxx if your child cannot attend.
Self-regulatory SMS	Reminder from [name of provider]: [name of child] has a vaccine appointment at school this [day of week]. Make a plan now for how [name of child] will get to school on-time on immunisation day. Please contact xxxx xxxx if your child cannot attend. Thank you.

SMS = short message service.

phone numbers to enable intervention delivery, (3) the school had not already completed the third and final school visit (in 2016, the HPV vaccine was delivered over three school visits in Victoria), (4) the school did not have a grade 6 cohort—to reduce the risk of contamination (i.e., parents/guardians talking about the reminders), based on the assumption that parents are more likely to communicate with each other when they share a longer history at the school. This resulted in 31 (28.70%) of the 108 schools being included in the study. No descriptive information was collected about schools not included in the study.

Sample

Of the 5,479 year 7 students enrolled in these schools 4,386 (80.05%) had consent to receive the HPV vaccine within the secondary school vaccine program and were therefore included in the study. Across all participants, the average age was 13.19 years (standard deviation = .40) with an equal gender balance (male = 49.92%). Almost all participants' parent/guardian mobile phone numbers were recorded on their school class list (92.29%) although the accuracy of the phone numbers was unknown. Most participants attended school in a metropolitan area (87.32%), and most participants attended a state government school (72.25%). None of the schools meeting the inclusion criteria were from the independent sector nor were there any special education or language schools.

Study design, randomization, and intervention

A single-blind multi-arm parallel randomized controlled trial was conducted. Students and parents/guardians were not actively informed about the study to prevent responder bias. Before the third HPV vaccination school visit, participating immunization providers sourced student data (name, age, gender, consent status, parent/guardian mobile phone number) from their vaccination database (i.e., each provider has their own immunization database to record and manage the vaccine program in their local government catchment area) and copied this into spreadsheets provided by the researchers (a spreadsheet was provided for each participating school). In each spreadsheet, the provider also recorded the date of the scheduled third school visit. The spreadsheets contained an embedded formula (i.e., Excel's RANDBETWEEN function) to randomly assign participating students (i.e., students whose parent/guardian had consented to their receiving the HPV vaccine within the school program) into one of three study conditions, with 1:1:1: allocation: motivational SMS versus self-regulatory SMS versus no SMS (control condition). Hence, randomization occurred within each school. Table 1 presents the SMS content for the intervention groups.

Providers then prepared the SMS data files and used their SMS service provider to distribute the reminders to parents/guardians of students in the intervention conditions two working days before the third school visit (one working day if the visit fell on a Monday or Tuesday). Only one reminder was sent per student, and the providers did not assess if the SMS was successfully delivered to the recipient.

Follow-up

Local government immunization providers also hold end-of-year catch-up sessions (e.g., at their local government office) for any student who may have missed a vaccine during the year. An extended follow-up period was used to evaluate both the impact of the intervention on the day of the third school visit, as well as from the day of the third school visit until the end of the 2016 school program. This recognizes that students who missed the vaccine at the school session may still later attend a local government catch-up session and receive the vaccine. If the effect of the interventions is restricted to the day of the school visit, then this would suggest that there is little benefit in using reminders as those who benefit from the reminder would have nevertheless attended a catch-up session and received the vaccine. After the 2016 school program (during January 2017), immunization providers again sourced student data (i.e., vaccination status and date of vaccination) from their vaccination database and merged this into their school-specific spreadsheets. They then removed all identifiable information from their school-specific spreadsheets and provided this nonidentifiable data (i.e., study condition, age, gender, consent status, vaccination status, and date of vaccination) and school data (i.e., date of third school visit and school sector—state government, Catholic, or independent) to the researchers. Figure 1 provides a summary of the key events and timelines of the trial.

Vaccine dose

Our primary focus was to assess whether the interventions encouraged students to receive the HPV vaccine, irrespective of the dose of the vaccine. However, we also assessed whether the intervention encouraged up-to-date students (i.e., students who had received dose 2 of the vaccine before the third school visit) to receive the third dose and complete the vaccine.

Figure 2 provides a flow diagram.

Sample size and statistical analyses

Sample size determination was difficult due to the lack of data on current rates of vaccination among consented students at the third school visit and due to a lack of research exploring the impact of message content on adolescent vaccination rates. We planned to detect a 3% point increase (90% coverage vs. 93% coverage). Considering a two-sided test with an alpha of .05 and statistical power of 80%, we estimated that 1,422 participants would be required for each group. Chi-square analyses of independence (using Bonferroni corrections for multiple comparisons) were conducted to assess whether sending an SMS

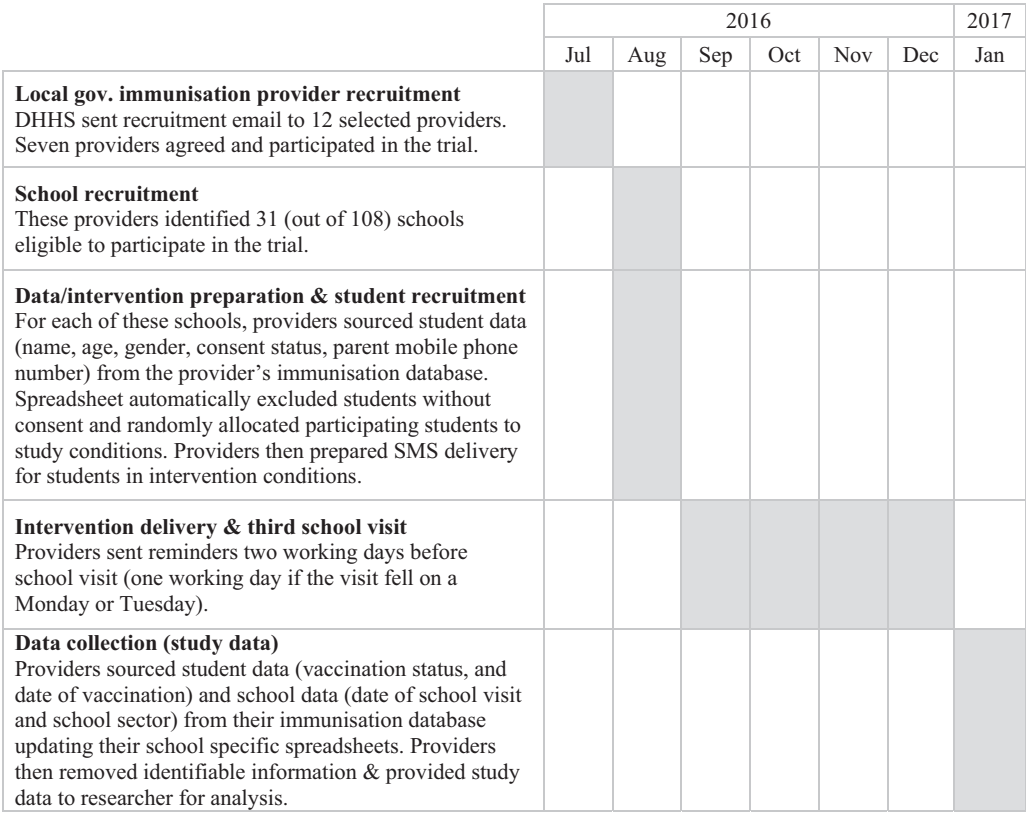

Figure 1. Study timeline and key events.

increased the likelihood of a student's receiving the HPV vaccine, and if so, which message was most effective. Logit regression analysis was conducted to calculate odds ratios (ORs) with 95% confidence intervals (CIs). Analyses were conducted using intention-to-treat analysis (i.e., all participants) and per-protocol analysis (i.e., only participants with a parent/guardian mobile phone number provided) on both follow-up periods (i.e., day of third school visit and extended follow-up period) and vaccine dose (i.e., any dose and dose 3 only). We also examined results by gender, although only at the descriptive level. Analyses were conducted using SPSS version 26 (IBM Corp., Armonk, NY). [33].

Results

There were no significant differences in demographic characteristics between the three study conditions (see Table 2), suggesting that the randomization process was effective at creating three equivalent groups.

As shown in Figure 3, 85.71% of consented students in the control condition received the HPV vaccine (any dose) at the third school visit, compared with 88.35% (2.64% point increase) in the motivational message condition, and 89.00% (3.29% point increase) in the self-regulatory message condition. Findings from the chi-square analysis (intention-to-treat analysis) revealed a statistically significant effect of study condition χ^2 (2, N = 4,386) = 8.31, p = .016. Post hoc analysis showed that the SMS conditions elicited higher vaccination rates at the third school visit than the control condition, χ^2 (1, N = 4,386) = 8.03, Bonferroni-corrected p = .010, OR = 1.31, 95% CI = 1.09–1.57. There was no significant difference in vaccination rates at the third school visit between the motivational and self-regulatory messages, χ^2 (1, N = 2,860) = .30, Bonferroni-corrected p =.584, OR = 1.07, 95% CI = .85–1.35. In other words, sending an SMS was effective at increasing vaccination rates at the third school visit, and both of the intervention messages were similarly effective. Results were equivalent when using the per-protocol analysis.

As illustrated in Figure 3, the extended follow-up period resulted in higher vaccination rates across the sample (as expected given that this also included students who attended a local government catch-up session after the date of the third school visit). Nevertheless, using this extended follow-up period, the pattern of results remained the same. Specifically, 88.66% of consented students in the control condition received the HPV vaccine (any dose) during the extended follow-up period, compared with 91.12% (2.46% point increase) in the motivational message condition, and 90.97% (2.31% point increase) in the self-regulatory message condition. Findings from the chi-square analysis (intention-to-treat analysis) again revealed a statistically significant effect of study condition, χ^2 (2, N = 4,386) = 6.44, p = .040. Also, post hoc analysis showed that the SMS conditions elicited higher vaccination rates than the control condition, χ^2 (1, N = 4,386) = 6.42, Bonferroni-corrected p = .011, OR = 1.30, 95% CI = 1.06–1.60), and again, there was no significant difference in vaccination rates between the motivational and self-regulatory messages, χ^2 (1, N = 2,860) = .02, Bonferroni-corrected p =1.00, OR = .98, 95% CI = .76–1.27. Results were equivalent when using the per-protocol analysis.

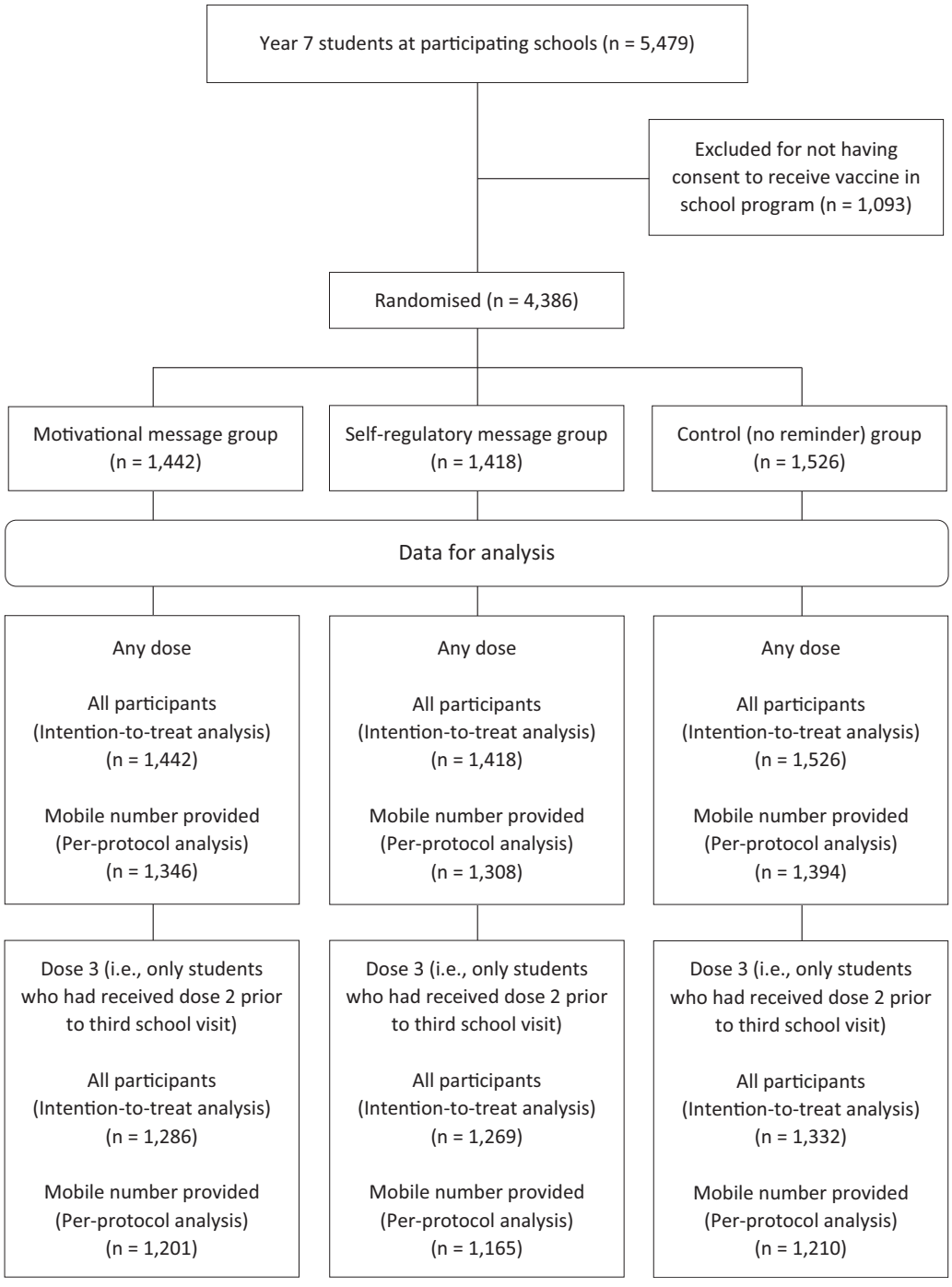

Figure 2. Study flow diagram.

The previously mentioned analyses investigated any dose of the HPV vaccine and so included all students who had consent to receive the vaccine within the school program. From these students, 3,887 (88.62%) were up-to-date (i.e., received dose 2 before the third school visit) and were the focus for examining the impact of the interventions on completion of the HPV vaccine schedule. In the control group, 95.87% of students received dose 3 on the day of the third school visit, and this increased to 98.95% for the extended follow-up period. In other words, nearly all up-to-date students received the vaccine, leaving little or no room for improvement among these individuals. Not surprisingly, the interventions had no impact, with no significant differences observed between any of the study conditions on the day of the third school visit, χ^2 (2, N = 3,887) = 1.38, $p = .503$, or for the extended follow-up period, χ^2 (2, N = 3,887) = .31, $p = .858$. Results were equivalent when using the per-protocol analysis.

Table 2
Characteristics of study population

	Total N = 4,386	Motivational SMS n = 1,442	Self-regulatory SMS n = 1,418	No SMS (control) n = 1,526	*p*
Male[a]	49.92%	48.86%	49.78%	51.03%	.512
Age[b]	13.19 (.40)	13.17 (.41)	13.21 (.39)	13.19 (.39)	.107
Mobile number available	92.29%	93.34%	92.24%	91.35%	.126
Metropolitan-based school	87.32%	86.41%	87.24%	88.27%	.311
State government school	72.87%	71.91%	74.19%	72.54%	.368

p value assesses differences between study conditions.
SMS = short message service.
[a] Data not available for 5.00% of sample.
[b] Data not available for 15.53% of sample.

There were no noticeable gender differences for any of the outcome variables. For example, in both the male and female participants, the vaccination rate (any dose) was higher in the motivational (male 87.86%; female 88.68%) and self-regulatory (male 86.90%; female 90.12%) message conditions than the control condition (male 84.19%; female 86.34%).

Discussion

This study found that use of SMS reminders to parents/guardians of eligible adolescents (i.e., students with consent to receive the vaccine within the Victorian secondary school vaccine program) significantly increased adolescent HPV vaccination rates within this program. Specifically, we found that the percentage of students receiving the vaccine (any dose) on the day of the third school visit increased by approximately three percentage points, and this benefit was maintained across the remainder of the calendar year supporting our hypothesis that SMS reminders would lead to greater uptake of the HPV vaccine within the program. However, there was no differential effect of behavioral messaging: The message which incorporated a self-regulatory strategy (i.e., implementation intentions) along with the message, which used a motivational strategy (i.e., highlighting susceptibility) were similarly effective at increasing vaccine uptake. The benefits of sending a reminder also appear to be restricted to individuals who had missed an earlier dose, as those students who were up-to-date with the vaccine (i.e., completed dose 2 before the third school visit) almost always completed the three-dose schedule even without the intervention.

The findings of this randomized control trial are consistent with several published systematic reviews in this field, which have found that overall, interventions using reminder strategies positively impact vaccination rates [34–37] and with studies specifically investigating SMS reminders to increase adolescent HPV vaccination rates [17,18]. However, there are two important differences between these and the present trial. First, our findings add to existing knowledge by examining the effect of reminders within a local government immunization provider delivered school-based vaccine program. These programs are arguably less susceptible to some of the barriers experienced in primary care settings (e.g., less dependent on parents/guardians remembering to book/attend a vaccination appointment), and therefore, there was potential that reminders may not have sufficient leverage to be effective in this setting. Our findings show that SMS reminders are an important tool in school-based vaccine programs. Second, previous research had not tested the impact that different SMS messages might have on vaccination rates. Our study is the first to test different behaviorally informed messages.

Several barriers were experienced in delivering the interventions. The success of SMS reminders is facilitated by almost universal access to and frequent use of mobile devices [38]. Currently, however, not all schools provide parents' mobile phone numbers to local government, and few provide a full set of student data in a readily usable format. For such an initiative to

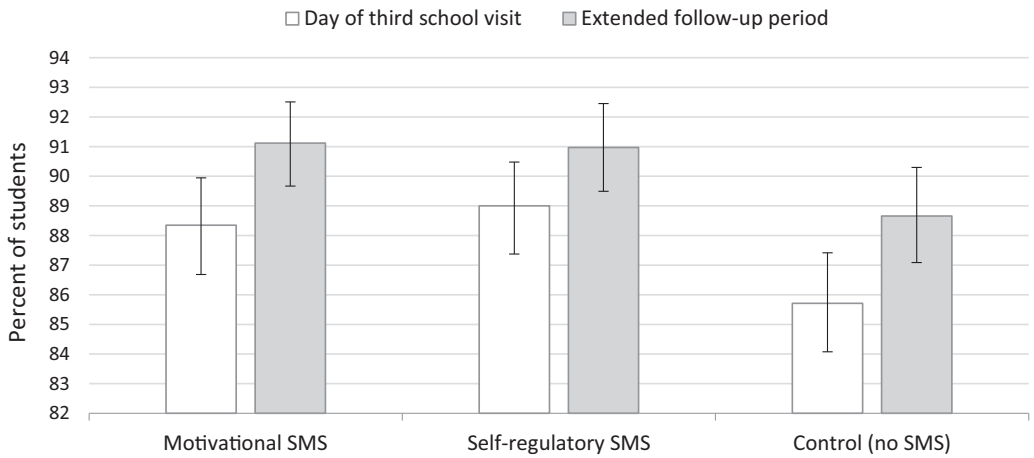

Figure 3. Vaccination rate (any dose) among students with consent, by study condition, on day of the third school visit and during the extended follow-up period (intention-to-treat analysis).

be adopted state-wide, additional efforts would need to be made to address existing data quality issues. Six complaints were received in relation to this trial, representing a complaint rate of .21%. All complaints pertained to the self-regulatory message. It may be that parents/guardians perceived that the self-regulatory message implied they were disorganized—however, this is speculative as details of the complaints were not made available. The discrepancy between the complaint rate of the self-regulatory message and the motivation message and the lack of any statistically significant difference between the response rates of these messages suggests that the motivational message should be used in further SMS messages.

Although this trial lifted vaccination rates, there remains room for improvement. Approximately 10% of students in the intervention conditions did not receive any dose of the HPV vaccine. Although it is possible that students may have received the vaccine elsewhere (i.e., in a primary care setting despite having consent to receive the vaccine within the school program), it is unlikely to account for all these students. A number of factors may account for why a student with consent missed the vaccine (e.g., student refused to receive the vaccine on the day of vaccinations, student skipped class during the time of the session, student is no longer attending the school since submitting the consent form at the beginning of the year); however, anecdotally, the primary reason is that students are not at school on the day of vaccination, and therefore, additional intervention approaches that seek to ensure student attendance may further help reduce this gap. Scope also exists to increase vaccine uptake by increasing consent card return rates. Approximately 20% of students did not have consent within the school program, and yet, vaccination refusal rates are estimated to be as low as 2% overall in Australia [39]. It appears that scope remains to improve on the results achieved in this trial by further targeting those who are not active vaccine refusers but have not returned a completed consent card. Finally, our findings suggest that the reminders primarily took effect among individuals who had a history of noncompliance with the vaccine. This suggests that vaccine completion rates would be increased if the reminders were used for the first/second school visits, so these individuals stay on-track to complete the vaccine schedule.

There were a number of strengths and limitations with this trial. Through close collaboration with state and local government, we were able to obtain a large sample of over 4,000 eligible adolescents/parents/guardians, a number that would be very difficult to achieve outside of an institutional setting in Victoria. Our ability to randomize students within schools into different study conditions was a notable strength, and blinding participants allowed us to avoid issues relating to responder bias. In terms of limitations, although the results suggest that the two message frameworks trialed may be equally effective, a "plain" (not theoretically informed) message may have worked just as well. Unfortunately, despite the relatively large sample size, it was nevertheless insufficient for including a fourth condition for testing a "plain" message. A further limitation of this study was that our sample was not representative of the broader school population. We restricted our study to schools serviced by providers who have a large number of schools in their catchment area (e.g., skewed toward metropolitan schools). Also, few schools met the inclusion criteria, and so the sample represented a particular school profile (e.g., the sample did not include any independent or special/language schools), and so our findings may not generalize to other school settings.

Our findings are also limited to the school vaccine program, and so the observed intervention effects are not at the total population level (i.e., all adolescents), but instead only pertain to adolescents who have consent to receive the vaccine within the school program. Although we considered the potential influence of gender, a range of other moderating factors was not considered. For example, we did not assess whether reminders take effect among particular population groups (e.g., vaccine-hesitant parents/guardians, non-English speaking households, adolescents who frequently attend primary care settings) or if intervention features other than "message content" may influence results (e.g., sending multiple reminders, sending reminders at the first or second school sessions).

In conclusion, SMS reminders to parents/guardians are an effective strategy for encouraging adolescents to receive the HPV vaccine within local government delivered school-based vaccine programs. The results demonstrate to policy-makers the potential of harnessing new media and behavioral science interventions to supplement traditional policy approaches, such as regulation, to optimize vaccination uptake. This strategy should therefore be used by local government immunization providers to optimize the population health benefits of the HPV vaccine. However, further research is required to determine the scalability and precise parameters required for successful state- and nation-wide reminder programs and to determine if using an SMS reminder is effective within independent and special/language schools, which were not included in this study. There is also opportunity to address effective ways of improving the provision of parent/guardian mobile phone number data from schools to their immunization provider. In addition, future research is required which includes a "plain" message condition to determine if the increase in attendance observed in the present study was influenced by the use of theoretically informed message content or if the simple act of receiving an SMS reminder is equally effective.

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