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The Influence of Parental Autonomous Motivation on Adolescent HPV Vaccine Initiation and Completion

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Abstract

Objective: Motivation is theorized to be a key determinant of behavior but has not been applied to human papillomavirus (HPV) vaccination. Autonomous motivation is hypothesized to be the most "self-determined" type of motivation and may contribute to parents' decisions to initiate and complete the HPV vaccine series. I examined patterns of association between motivation types and HPV vaccination as well as the pathways linking autonomous motivation with intentions to vaccinate.

Methods: As part of a larger project, parents (N=177) of unvaccinated adolescents completed a survey including a measure of parental motivation for adolescent vaccination. After 12 months, I reviewed electronic medical records to obtain HPV vaccination coverage data. I used logistic regression models to determine which motivation types—autonomous, introjected, or external—were associated with one- and three-dose coverage. I examined ordinal regression models to assess the overall effect of motivation on HPV vaccine coverage. Additionally, I tested competing models of the direct effect of autonomous motivation and the indirect effect through other psychosocial variables to determine which pathway(s) best explain the relationship between autonomous motivation and intentions to vaccinate.

Results: Results indicate autonomous motivation is a significant predictor of 1-dose coverage (OR = 2.47; 95%CI: [1.202, 5.079], p = .01) and of 3-dose coverage (OR = 2.68; 95%CI: [1. 00, 7.18], p = .05). Ordinal regression models confirmed greater autonomous motivation is associated with increased likelihood of pursuing HPV vaccine coverage (OR = 2.452, 95% CI = 1.257 - 4.786, p = .009). There were no significant effects of introjected or external motivation on one- or three-dose coverage (*p*s > .142). Moreover, a model with both direct effects of autonomous motivation on intentions and indirect effects via attitudes best fit the data.

Conclusions: Findings support the utility of distinguishing the type of underlying motivation for adolescent HPV vaccination. Autonomous motivation, rather than introjected and external motivation, was positively associated with one- and three-dose coverage. Thus, autonomy-supportive interventions to promote parents' beliefs that the HPV vaccine is important and beneficial to their child's health may be a useful mechanism for increasing rates of completion of the vaccine series.

The Influence of Parental Autonomous Motivation on Adolescent HPV Vaccine Initiation and Completion

Despite well-demonstrated benefits of vaccinating against human papillomavirus (HPV), including protection against several types of cancer and genital warts, rates of adolescent vaccine coverage remain low. Motivation is theorized to be a key determinant of behavior (Deci & Ryan; 1985), and research has demonstrated autonomous motivation—motivation due to the experience of volition and belief in the value and importance of a behavior—facilitates behavior performance and maintenance (Ryan & Deci, 2000). Accordingly, autonomous motivation may be influential in decisions to receive the required three doses of the HPV vaccine. Autonomous motivation, more than other types of controlled motivation, may contribute to parents' decisions to get the first dose of the vaccine as well as decisions to return for follow-up doses. The current study tested the effects of motivation on HPV vaccine initiation and completion and explored the pathways by which motivation might influence parents' decisions to vaccinate their children.

Since the inception of the HPV vaccine in 2006, vaccine initiation and completion rates have been suboptimal. Although HPV is the leading cause of cervical cancer, anogenital cancer, and genital warts (CDC, 2015), series initiation (65.1% for girls and 56% for boys) and completion (49.5% for girls and 37.5% for boys) rates remain below the *Healthy People 2020* goal of 80% three-dose coverage (Office of Disease Prevention and Health Promotion [ODPHP], 2016; Walker et al., 2017). The CDC (Walker et al., 2017) recommends the vaccine for girls and boys ages 11 to 12 and catch-up vaccination for men up to age 21 and women up to age 26. Previous guidelines were for all individuals to receive three doses of the vaccine. However, in the fall of 2016, the Advisory Committee on Immunization Practice (ACIP) changed their recommendation for individuals initiating the vaccine series before their 15th birthday to two doses received six months apart (Robinson et al., 2018). For individuals beginning the series on, or after, their 15th birthday, the recommendation is to receive three doses of the vaccine (on a 0, 2-, and 6-month schedule; Robinson et al., 2018). Despite receipt of doctor's recommendation, many parents remain undecided about the HPV vaccine and fail to vaccinate their children. Completion of the vaccine series is key to cancer prevention as partially vaccinated individuals may not be entirely protected from HPV (Widdice et al., 2011), and factors impeding completion must be clarified. Reviews of the literature have identified factors influencing vaccine initiation (Bartlett & Peterson, 2011; Garcini et al., 2012; Kessels et al., 2012); however, predictors of completion have been largely ignored (Holman et al., 2014). Self-Determination Theory (SDT) suggests that behavior will be initiated and maintained if it is autonomously motivated (Deci & Ryan, 1985, 2008). Concerning HPV vaccination, successful initiation and completion of the vaccine series is theorized to result from personally valuing vaccination and its associated health benefits (i.e., cancer and genital wart prevention). Thus, autonomous motivation may be an influential factor in decisions to vaccinate.

Self-Determination Theory posits that motivation occurs along a continuum, from self-determined to controlled (Deci & Ryan; 1985; Deci & Ryan, 2008; Williams et al., 1996). Autonomous motivation is considered to be the most "self-determined" form of motivation and underlies behaviors performed because they are valued and believed to be important. Further, autonomous motivation entails internalization of values. For example, an autonomously motivated parent might get the HPV vaccine for their adolescent because it matches with an overall goal of supporting their child's health. External motivation underlies behaviors performed due to outside pressures and is the most "controlled" type of motivation. External motivation implies no internalization of beliefs and underlies behavior performed to gain a reward or avoid a punishment (Ryan et al., 2008; Williams et al., 1996; Williams et al., 2006). A parent who vaccinated their adolescent to make their partner or their healthcare provider happy would do so because of external motivation. In the middle of the spectrum, between autonomous and external motivation, is introjected motivation. Introjected motivation is theorized to describe partially internalized beliefs and values (Howard, Gagné, & Bureau, 2017; Ryan et al., 2008; Williams et al., 1996; Williams et al., 2006). Behaviors inspired by introjected motivation are performed to avoid a sense of guilt or shame. For example, a parent vaccinating their adolescent to avoid feeling bad about himself/herself would do so because of introjected motivation. In the context of HPV vaccination, one would expect parents who are autonomously motivated to vaccinate their adolescents to be most likely to initiate the series.

Individuals who are autonomously motivated are more likely to perform health behaviors (Deci & Ryan, 2008). The positive effect of autonomous motivation on health behavior performance has been demonstrated across a wide variety of behaviors including physical activity performance, weight loss, smoking cessation, and diabetes management (Kennedy, Goggin, & Nollen, 2004; Williams et al., 1996; Williams et al., 2002). Theoretically, increased identification with values will lead to an increased sense of personal volition (Deci & Ryan, 2008). In contrast, studies examining introjected and external motivation demonstrate neutral or negative associations with health behaviors such as physical activity performance, weight loss, and glycemic control (Edmunds, Ntoumanis, & Duda, 2006; Levesque et al., 2007; Standange, Sebire, & Loney, 2008; Williams et al., 1996; Williams et al., 2002; Wilson, Rodgers, & Fraser, 2002; Wilson et al., 2003; Wilson et al., 2006). Taken together, findings from work in other health domains suggest that differentiating between types of motivation may be beneficial for promoting HPV vaccination.

Previous work examining HPV vaccination has identified several factors that are associated with HPV vaccine initiation (Brewer et al., 2011; Fuchs et al., 2016; Gerend & Shepherd, 2012; Thomas et al., 2012). Intentions, or plans to attain a behavioral goal, significantly predict initiation of the HPV vaccine (Brewer et al., 2011; Gerend & Shepherd, 2012). Attitudes, or beliefs about the outcome of health-related behavior, are also related to vaccine initiation, and this effect is proposed to occur through attitudes impact on intentions (Ajzen, 1996; Bastani et al., 2011; Gerend & Shepherd, 2012). However, intentions do not necessarily translate into behavior, and these variables leave a considerable amount of variance in behavior unexplained (Hagger et al., 2002; Norman & Conner, 2005; Sheeran & Abraham, 2003).

Examining motivation can give insights into the reasons parents engage in behavior, so motivation, theorized to be an antecedent to intentions (Hagger & Chatzisarantis, 2014), may explain variance in decisions to vaccinate above and beyond parents' intentions. A parent may be compelled to vaccinate their adolescent because they believe vaccination will be best for their child's future health, to avoid feelings of guilt, or because they are seeking the approval of their doctor. SDT, however, suggests that more self-determined forms of motivation are more likely to lead to behavioral adoption than controlled types of motivation (Deci & Ryan, 2000). While parents may be motivated to vaccinate their children for a variety of reasons, parents who experience autonomous motivated may be more inclined to move forward with vaccination than parents with greater introjected or external motivation (Deci & Ryan, 2000; Howard, Gagné, & Bureau, 2017). While studies have examined the influence of motivation as it pertains to other health behaviors (e.g., smoking cessation, weight loss), it has not been applied to studies of vaccination behavior. Accordingly, autonomous motivation may hold promise in facilitating decisions to initiate the vaccine series.

Despite an accumulation of studies examining predictors of vaccine initiation, a review of the literature by Holman and colleagues (2014) found there is relatively little work exploring predictors of vaccine completion. Researchers have, however, identified several barriers impacting completion including forgetting, lacking awareness of the necessity of follow-up doses, and being too busy to return to the clinic (Holman et al., 2014; Kouyoumdjian & Bailowitz, 2011). Information on psychological factors that facilitate completion will allow us to address suboptimal completion rates.

One factor that may contribute to low completion rates is differences in types of motivation. For example, autonomous motivation may explain which parents return to obtain follow up doses of the HPV vaccine to complete the series. Deci and Ryan (1985) suggested that the distinction between self-determined and controlled motivation is of particular importance in the prediction of the long-term maintenance of behavior. Several studies support the relationship between autonomous motivation and maintenance of various health behaviors, such as weight loss (Williams et al., 1996), smoking cessation (Williams & Deci, 1996; Williams et al., 2006), and medication adherence (Williams et al., 2009). The effect of autonomous motivation on behavior maintenance is also evident in HIV-medication adherence (Kennedy, Goggin, & Nollen, 2004), glycemic control (Williams et al. 2004) and physical activity performance (Kinnafick, Thøgersen-Ntoumani, & Duda, 2014; Wilson et al., 2006).

Autonomous rather than introjected and external motivation may be particularly salient in the completion of the HPV vaccine series. Parents who have internalized the benefits of vaccination and perceive themselves as having chosen to vaccinate their children because of these benefits (i.e., parents who are autonomously motivated) would be more likely to overcome barriers to vaccination and receive the requisite follow-up doses. Successful completion of the series would not result from introjected or external reasons for vaccination as an individual vaccinating their child to avoid feelings of guilt, or to please their provider, has not personally endorsed the behavior and feels no genuine willingness to maintain activities for vaccine completion. Given these theoretical and empirical distinctions, the examination of the motivation underlying vaccination may allow us to understand the decisions to pursue further doses of HPV vaccination.

Though SDT provides useful explanations for the reasons people engage in a behavior, it does not explain the processes by which motivation translates into behavior. Previous work has suggested that having greater self-determined motivation can lead to the development of positive attitudes and beliefs towards a behavior as well as higher perceived control, or competence (Williams et al., 1996; Williams et al., 2006). This process is suggested to occur through the internalization of beliefs whereby people are predisposed to form beliefs consistent with their motivation (Hagger & Chatzisarantis, 2009). Attitudes towards behavior and perceived control, or self-efficacy, both appear in the Theory of Planned Behavior (TPB, Ajzen, 1991). Thus, incorporating autonomous motivation into the TPB may explain the process by which motivation translates into behavior.

Hagger & Chatzisarantis (2009; 2014) proposed an integration of autonomous motivation and TPB in the Integrated Behavior Change Model (IBC) that conceptualizes autonomous motivation as a precursor to the belief-based predictors in TPB with indirect effects on intentions and behavior. Hypothesized connections between belief-based constructs in TPB (i.e., attitudes, self-efficacy, and norms) and self-determined motivation (i.e., that increased autonomous motivation leads to more positive attitudes and higher self-efficacy and thus, increased intentions and behavior performance) support the integration of autonomous motivation into the TPB. However, this integrated model and the purported indirect effects of autonomous motivation on behavior via TPB variables have not been applied to HPV vaccination.

Clarifying the pathways through which autonomous motivation influences behavior would facilitate the identification of psychological factors that are critical determinants of vaccination. The IBC model (Hagger & Chatzisarantis, 2014) suggests an indirect effect of autonomous motivation on both intentions to vaccinate and vaccine initiation through attitudes, self-efficacy, and subjective norms. However, SDT suggests autonomous motivation directly influences behavior. Additionally, there is evidence to suggest autonomous motivation may contribute to the prediction of health behaviors over and above vaccine intentions and the predictors included in the TPB (Ajzen, 1991; Hagger et al., 2002; McLachlan & Hagger, 2011). Thus, the role and importance of autonomous motivation differ between the IBC model and SDT. Previous work integrating autonomous motivation into the TPB has not compared the potential role of autonomous motivation as a proximal or distal factor influencing behavior.

Brewer and Gilkey (2012) described two different methods of testing health behavior theories: a summary approach and a competitive hypothesis testing approach. To test theories using a summary approach, all predictors of two theories are measured, and the respective overall model fit and variance explained are compared to determine which theory best predicts the outcome. However, Brewer and Gilkey (2012) posit that use of a summary approach may be less appropriate when considering that theories are often “cross-pollinated” and rarely applied as initially proposed. Thus, they suggest an alternative, more flexible means of theory comparison: competitive hypothesis testing. In competitive hypothesis testing, areas where two theories have differing explanations for associations between variables are identified and compared with the data. Though not common in health behavior research, competitive hypothesis testing could facilitate the identification of pathways critical to the application of theory to behavior (Brewer & Gilkey, 2012). The role of autonomous motivation in predicting behavior differs across theories. SDT argues that autonomous motivation directly influences behavior as a proximal influence, while the IBC theory conceptualizes autonomous motivation as a distal factor that affects behavior via its effect on attitudes, self-efficacy, norms, and intentions. Application of competitive hypothesis testing, rather than a summary approach, allows for testing of the alternative hypotheses by which autonomous motivation influences HPV vaccination.

Current Study

HPV vaccination rates remain suboptimal despite efforts to describe impediments and design interventions to promote early vaccination. To date, SDT and motivation have not been applied to the prediction of HPV vaccination. The present study aims to identify the effects of different types of motivation on vaccination behavior and to describe the mechanisms by which motivation may influence vaccination behavior among undecided parents. Autonomous motivation shows significant promise in explaining reasons for vaccination and providing a potential target for interventions to increase vaccine coverage.

The objectives of this study are 1) to examine the relationships between different types of motivation and HPV vaccination initiation and completion, and 2) to test the pathways linking autonomous motivation, vaccine initiation, and attitudes, norms, self-efficacy, and vaccine intentions. I chose to focus on these variables because of previous work positing the integration of autonomous motivation and the TPB (Hagger & Chatzisarantis, 2009; 2014). To determine and quantify the effects of motivation on HPV vaccination initiation and completion, I conducted a secondary analysis of data from a larger study to design and test the effects of a tablet-based intervention to promote HPV vaccination among undecided parents. I examined the influence of motivation on two primary outcomes: one-dose coverage (i.e., receipt of one or more doses of the vaccine), and three-dose coverage (i.e., receipt of three doses of the vaccine). I predicted that, consistent with SDT and previous work in other domains, autonomous motivation would be a stronger predictor of vaccination behavior than introjected and external motivation. In addition to these outcomes, to determine the effect that the changed dosing recommendations by the ACIP might have on the relationship between motivation and completion of the vaccine series, I examined the influence of motivation on a broader definition of completion that included the ACIP's new guidelines of receiving 2 doses over 6 months for individuals who began the vaccine series before age 15— “up-to-date” coverage. To test the alternative explanations of the role of autonomous motivation in influencing HPV vaccination proposed in SDT and the IBC model, I compared models comprising the direct and indirect effects of autonomous motivation via attitudes, norms, and self-efficacy on intentions to vaccinate and one-dose coverage. Explicitly, I tested the following research questions and associated hypotheses:

RQ1. To what extent do the three types of motivation (autonomous, introjected, and external) predict HPV vaccine series initiation (i.e., one-dose coverage)?

a. I hypothesized that autonomous motivation would be a stronger predictor of HPV vaccine initiation than introjected and external motivation.

RQ2. To what extent do the three types of motivation (autonomous, introjected, and external) predict HPV vaccine series completion (i.e., three-dose coverage or up-to-date coverage)?

a. I hypothesized that autonomous motivation would be a stronger predictor of HPV vaccine completion than introjected and external motivation.

To test the competing pathways linking autonomous motivation to intentions to vaccinate and HPV vaccination, I tested competing models (i.e., direct versus indirect pathways) to address the questions:

RQ3. Does autonomous motivation a) directly influence intentions to vaccinate or b) indirectly influence intentions via attitudes, norms, and self-efficacy?

RQ4. Does autonomous motivation a) directly influence one-dose coverage or b) indirectly influence initiation via vaccine intentions?

Method

Data for the study was collected as part of the baseline survey of a multi-stage project to develop and test a tablet-based self-persuasion intervention to promote HPV vaccination among undecided parents (Baldwin et al., 2017; Shay et al., 2016; Tiro et al., 2016).

Participants

Demographics for parent participants and their adolescent are presented in Table 1. Participants (*N* = 177) consisted of undecided parents of unvaccinated adolescents ages 11-17 identified through weekly electronic health record (EHR) reports identifying unvaccinated adolescents. Of the 177 participants, 36.7% (*N*=65) initiated the vaccine series, and 15.3% (*N*=27) received three doses by one-year follow-up. The number of individuals completing the series increased when considering those who met criteria for completion based on ACIP guidelines (*N*=3). The majority of the sample was female (97.2%), Spanish-speaking (58.8%), and Hispanic (68.9%). The majority of adolescents were also Hispanic (67.2%), and there was a nearly even split by adolescent sex (52.5% male). Parkland is a safety-net hospital serving low income, under- and uninsured populations in Dallas, TX. The IRB committees of both Southern Methodist University and the University of Texas Southwestern approved the study. Informed consent was obtained from all participants, and participants were compensated with a $5 gift card for completion of the survey.

Eligibility Criteria. Parents of eligible patients were mailed a letter inviting them to participate and provided with a toll-free number to ask questions or refuse participation. Invitation letters were sent in English or Spanish based on preferred language listed in the EHR. Bilingual research assistants then called parents of eligible patients, explained the project, and asked them to report their decision stage about the vaccine. Decision stage was assessed with a single item, "*Which of the following best describes your thoughts about getting the HPV vaccine for your [daughter/son]?*" Responses options included: (1) *I have never thought about getting the HPV vaccine for him/her,* (2) *I am undecided about getting the HPV vaccine for [her/him],* (3) *I do not want to get the HPV vaccine for [her/him],* and (4) *I do want to get the HPV vaccine for [her/him]*. Parents in the first two stages (i.e., never thought about the vaccine, undecided) were invited and consented. The research assistant then administered the baseline survey over the telephone.

Measures

Participants responded to the measures below on a 5-point Likert scale with answers ranging from (1) *strongly agree* to (5) *strongly disagree.* Scales were reversed such that higher values represented stronger agreement to simplify interpretation of analyses. Thus (1) represented *strongly disagree* and (5) represented *strongly agree*. Items were averaged within each scale to create mean scores. All items were adapted from previous research and displayed adequate reliability. Descriptive information for all items and constructs is displayed in Table 2.

Motivation. Motivation was assessed with the Treatment Self-Regulation Questionnaire (TSRQ), a well-validated measure of motivation in health behavior (Levesque et al., 2007), which has been successfully modified for application to HPV vaccination (Denman et al., 2016). The modified TSRQ consists of eight items assessing the different types of motivation. The stem for the eight items was *"The reason you would get [child's name] the vaccine is because…"*. Items reflected three different types of motivation along the continuum. Four items represented autonomous motivation— e.g., *"…because it is consistent with your goals as a parent."* Two items represented introjected motivation— e.g., *"you would feel guilty or ashamed if you did not."* Two items represented external motivation— e.g., *"you feel pressure from others to do so."* Responses within the three subscales were averaged to create mean scores for each scale.

Self-Efficacy. Self-efficacy was assessed with two items reflecting participants' confidence in their ability to get their child the vaccine in the face of barriers [e.g., "*You are confident that you can get the HPV vaccine for your child even if it means going to the clinic three times"* (Gerend & Shepherd, 2012)].

Intentions to Vaccinate. Intentions were assessed with three items asking about the likelihood of parents vaccinating their children [e.g. *"In the next year, how likely is it that you will get the HPV vaccine for your child?"* (Gerend & Shepherd, 2012)].

Subjective Norms. Subjective norms were assessed with eight items that reflected the influence of friends and family in decision-making about the vaccine [e.g., *"Your friends influence your decision about getting your child the HPV vaccine"*) (Allen et al., 2009; Gerend & Shepherd, 2012)].

Attitudes. Attitudes were assessed with six items that assessed parent's beliefs regarding the positive nature of HPV vaccination for their adolescents [e.g. *"Getting my child the HPV vaccine could save my child's life"* (Bynum et al., 2013; Gerend & Barley, 2009)].

Vaccination Behavior Outcomes. An electronic health record data pull on medical procedure codes matching administration of doses for the HPV vaccine yielded information on vaccination status, the number of received doses, and dates of vaccination one year after the date of randomization into the study. Vaccine initiation was operationalized as one-dose coverage (i.e., receipt of one or more doses of the vaccine within the 12-month study period). Thus, coding for one-dose coverage was inclusive of individuals who later received doses two and three of the vaccine. Vaccine completion was operationalized as three-dose coverage (i.e., receipt of 3 doses of the vaccine within the study period). I also examined a broader definition of coverage—up-to-date status- to determine the influence that changes in ACIP guidelines might have on the relationship between motivation and vaccination behavior.

One-Dose Coverage. One-dose coverage was coded as a dichotomous variable—individuals with 1 or more dose of the vaccine in their health record were given a 1 (N= 65), and those without a vaccine dose received a 0. Thus, one-dose coverage included individuals who also received doses two and three of the vaccine.

Three-Dose Coverage. Three-dose coverage was coded as a dichotomous variable—individuals with three doses of the vaccine were given a 1 (N= 27), and those with < 3 doses were given a 0.

Up-to-Date Coverage. Up-to-date coverage was conceptualized as a less-stringent definition of completion than three-dose coverage and counted individuals as having completed the vaccine series if they met the ACIP's new recommendations (Robinson et al., 2018). Adolescents were considered to be up-to-date if they had received three doses over the 12-month study period, or if they had received two doses *and* the first dose was received before age 15, *and* the lag between doses 1 and 2 was at least six months. Up-to-date coverage was coded as a dichotomous variable—individuals who were up-to-date were given a 1 (*N*= 30), and those who had not met the new ACIP criteria or received three doses received a 0. Thus, coding for up-to-date coverage included all individuals who counted in three-dose coverage as well as individuals who had completed based on the new guidelines (*N*= 3).

Analytic Approach

Analyses were conducted using IBM SPSS version 22 and MPlus version 8 software (Muthén & Muthén, 2012). Before data analysis, descriptive statistics were run on study variables (Table 1). Chi-square analyses were completed to determine group differences in predictors by parent's preferred language, adolescent age, and adolescent sex. Additionally, I tested for differences between clinics. As data were drawn from a larger study to develop a tablet intervention to promote HPV vaccination, some participants ($n = 35$) were exposed to the intervention materials. Additionally, participants ($n = 92$) recruited for a different arm of the study were recruited based on an impending doctor's visit. These factors might have impacted vaccination rates. To account for these differences and other differences based on sociodemographic variables, all regression analyses controlled for recruitment arm, preferred language, adolescent age, and adolescent sex. There were no significant differences by clinic ($p > .05$), so this variable was not included as a covariate in analyses.

Motivation Predicting HPV Vaccine Coverage.

Logistic Regression Models.

To determine whether autonomous, introjected and external motivation predicted the likelihood of one-dose coverage and three-dose coverage, I conducted multivariable (including autonomous, introjected, and external motivation as predictors) logistic regression models for each outcome. Because changes in ACIP guidelines might impact the relationship between motivation and vaccine completion, I conducted an additional multivariable logistic regression models predicting the likelihood of up-to-date coverage.

Ordinal Regression Models.

To determine the influence of the different types of motivation on overall HPV vaccine coverage, I also conducted ordinal (proportional odds) regression analyses. Ordinal regression analyses predict the increased likelihood of an outcome that contains three or more ordered categories (e.g., receipt of dose two following receipt of dose one and receipt of dose three following receipt of the first two doses), based upon a one-unit change in the predictor. Ordinal regression is preferred to logistic regression models when the outcome has multiple categories as it preserves the information across categories that is lost when the outcome is "dichotomized" and when the distance between ordered categories is not equal. In the example of HPV vaccination, there are multiple transitions between doses (i.e., from 0 to 1 dose, 1 dose to 2 doses, and 2 doses to 3 doses) and these transitions between doses vary in terms of time and effort (e.g., returning to the clinic for more doses outside of the annual visit schedule). Ordinal regression models assume the effect of the predictors is consistent across categories (the assumption of proportional odds) and thus provide an estimate of the overall effect of the predictors on the outcome. A multivariable ordinal regression was conducted to determine the effects of autonomous, introjected, and external motivation on vaccination behavior (i.e., receipt of zero, one, two, or three doses).

Competitive Hypothesis Testing of Direct and Indirect Paths.

To determine whether the effect of autonomous motivation on intentions to vaccinate and vaccination behavior is direct or indirect, I used a competitive hypothesis testing strategy. I compared nested models comprising the competing hypotheses of direct and indirect effects of autonomous motivation on intentions and vaccination based on chi-square difference tests. Using SDT and the IBC model as guides, I fit the following three models separately for each outcome as described in research questions 3 and 4: 1) a model with both direct *and* indirect pathways, 2) a model with only indirect pathways, 3) and a model with only direct pathways. Structural equation modeling was performed in MPlus version 8. For analyses predicting intentions to vaccinate, I used a maximum likelihood (ML) estimator. For analyses in which one-dose coverage was the outcome, I used a weighted least squares means and variance adjusted estimator (WLSMV) for modeling purposes to account for the dichotomous outcome and non-normally distributed predictors (Kline, 2016). Latent factors were estimated for all constructs, and a measurement model was estimated. All factor loadings for latent variables were significant ($ps < .001$) and coefficient alpha was acceptable for all scales (Table 2).

The model with only direct pathways and the model with only indirect pathways were nested within the model with both direct *and* indirect pathways. These nested models allow for comparisons to determine whether both direct and indirect paths are necessary to maintain model fit. If model fit is reduced when comparing the model with both direct and indirect pathways to the model with only direct pathways, the indirect pathway is needed. If model fit is not reduced, according to the principle of parsimony, the indirect pathway can be removed (Raykov & Marcoulides, 1999). For research question 3 (*Does autonomous motivation a) directly influence intentions to vaccinate or b) indirectly influence intentions via attitudes, norms, and self-efficacy?*), my first model with both direct and indirect effects (as shown in Figure 1) hypothesized a direct path from autonomous motivation to vaccine intentions and three indirect paths via attitudes, self-efficacy, and norms. My second model included only the direct path from autonomous motivation to vaccine intentions (c1), and my third model included only indirect effects with the three pathways to intentions via self-efficacy, attitudes, and norms (a1 x b1, a2 x b2, a3 x b3). Parameter estimates are interpreted as regression coefficients.

For research question 4 (*Does autonomous motivation a) directly influence one-dose coverage, or b) indirectly influence initiation via intentions?),* my first model with direct and indirect effects (as shown in Figure 2) hypothesized a direct path from autonomous motivation to one-dose coverage and an indirect path via intentions (Fig 2). My second model included only the direct path from autonomous motivation to one-dose coverage (c1), and my third model included only the indirect effect with the pathway from autonomous motivation to one-dose coverage via intentions (a1 x b1).

To determine which model best fit the data within each hypothesis, I compared models by calculating the χ^2 difference test statistic. A significant difference test statistic indicates the hypothesized model with the lower chi-square value fits the data better. A nonsignificant statistic suggests the more parsimonious model is best (Raykov & Marcoulides, 1999). The informal model fit was also assessed by computing the comparative fit index (CFI; values between .90 and .95 indicate adequate fit), root-mean-square error of approximation (RMSEA; values < .08 indicate adequate fit and values < .06 indicate good fit), and chi-square values (Kline, 2016).

Results

Participant Characteristics

Demographics for parent participants and their adolescent are presented in Table 1. There were no significant differences in motivation (autonomous, introjected, or external) across recruitment arm or adolescent gender (*ps* > .05). However, Spanish-speakers demonstrated significantly higher levels of autonomous and introjected motivation (*ps* <.001). No significant differences by language were evident in external motivation (p = .09). Additionally, chi-square analyses indicated significant differences in one-dose coverage based on recruitment arm and parent-preferred language. Spanish speakers were more likely to initiate the vaccine series than English-speakers (p =.03). Moreover, there was a trend for adolescent gender to suggest that parents of adolescent females were more likely to initiate the vaccine than parents of adolescent males (p = .06). Independent samples t-tests were examined to determine differences in one-dose coverage by age. Younger adolescents were more likely to initiate the vaccine series ($p < .001$). To control for these differences, all regression models included adolescent age, gender, parent preferred language, and recruitment arm as covariates.

Motivation Predicting HPV Vaccine Coverage

Logistic Regression Models.

Autonomous motivation was associated with increased odds of one-dose coverage (i.e., receipt of one or more doses) in a multivariable, logistic regression model (*OR* = 2.47; 95%CI: [1.202, 5.079], p = .01). As predicted, neither introjected nor external motivation showed a significant effect in predicting one-dose coverage (Table 3). In a multivariable logistic regression model predicting three-dose coverage (i.e., receipt of three doses), greater autonomous motivation predicted three-dose coverage (*OR* = 2.68; 95%CI: [1. 00, 7.18], p = .05), but neither introjected, nor external motivation showed significant influence on three-dose coverage (ps > .05; Table 3). However, in a multivariable logistic regression model predicting up-to-date coverage, there were no significant effects of autonomous, introjected, or external motivation (ps > .05; Table 3). So, autonomous motivation predicted greater likelihood of vaccine initiation and completion (receipt of three doses), but there were no significant predictors of up-to-date coverage.

Ordinal Regression Models.

A cumulative odds ordinal logistic regression with proportional odds was conducted to determine the effects of the three different types of motivation on vaccination behavior (Table 4). The assumption of proportional odds was met, as assessed by a full likelihood ratio test comparing the fit of the proportional odds model to a model with varying location parameters, (p= .27). This indicates the influence of autonomous motivation was consistent across each transition between doses. An increase in autonomous motivation was significantly associated with greater odds of overall HPV vaccine coverage (OR = 2.452, 95% CI = 1.257, 4.786, p = .009). However, consistent with logistic regression models, there were no significant associations between introjected and external motivation and HPV vaccine coverage (ps > .05). Consequently, results are indicative of a positive association between autonomous motivation and overall HPV vaccine coverage.

Competitive Hypothesis Testing of Direct and Indirect Paths

A measurement model with all latent constructs was estimated. All factor loadings were significant, and the measurement model displayed adequate fit (χ^2=223.10; CFI= .935; RMSEA= .058, 90% CI = .043, .072). Bivariate correlations between all latent constructs are displayed in Table 5.

When I examined the effect of motivation on intentions, the model with both direct and indirect pathways (see Figure 3) fit the data better than both the model with only indirect pathways from autonomous motivation to intentions (χ^2 difference = 6.697, p = .01; Supplementary Figure 1) and the model with only direct pathways to intentions (χ^2 difference = 86.194, p <.001; Supplementary Figure 2), suggesting both direct and indirect paths to intentions. Model comparisons are displayed in Table 6. Of note, the presence of both direct and indirect pathways from autonomous motivation to intentions is contrary to the IBC, which proposed only indirect paths from autonomous motivation to intentions. Significant predictors of intentions included attitudes (standardized coefficient .32) and autonomous motivation (.39). Autonomous motivation showed significant associations with self-efficacy (.29), attitudes (.76), and subjective norms (.37). The indirect path from autonomous motivation to intentions via attitudes (.25) was also significant. Self-efficacy and subjective norms were not significantly associated with intentions to vaccinate (Figure 3). Thus, only an indirect effect of autonomous motivation through attitudes towards vaccination was evident.

Examination of regression coefficients in the model with only indirect paths (See Supplementary Figure 1) and the model with only direct paths (Supplementary Figure 2) confirmed that across all three models, neither self-efficacy nor subjective norms showed significant associations with intentions. Within the model with only indirect paths, autonomous motivation showed significant associations with self-efficacy (.29), attitudes (.79), and subjective norms (.36) and the indirect path between autonomous motivation and intentions via attitudes was significant (.54, p<.001). Within the model with only direct paths (Supplementary Figure 2), both autonomous motivation and attitudes showed significant associations with intentions (.43, p< .001 and .41, p=.002, respectively).

Attempts to estimate models describing the effect of autonomous motivation on vaccination behavior were adversely impacted by small sample size and, consequently, demonstrated poor fit. Compared to analyses using maximum likelihood estimators, models using weighted least squares means with variance adjustment (WLSMV) are less efficient and require larger sample size to achieve adequate power. Bandalos (2014) showed that with small samples sizes (less than 200) power for WLSMV estimation is often low and standard error bias is high, but that as sample size increased error rates decreased and approached a nominal rate around a sample size of 500. Thus, these models were not deemed to be reliable and were not interpreted. Consequently, a determination of whether autonomous motivation has a direct, or indirect, effect on one-dose coverage could not be made at this time.

Discussion

Although motivation has been applied to numerous health behaviors, this research is some of the first to examine the effects of motivation in the context of HPV vaccination. Consistent with predictions based on Self-Determination Theory, these results suggest greater autonomous motivation, rather than introjected or external motivation, is associated with increased likelihood of both one- and three-dose coverage of the HPV vaccine. Thus, these findings strongly suggest that, for HPV vaccination, different types of motivation are important in parents' decisions to vaccinate. Many past studies have demonstrated the importance of autonomous motivation in predicting health behavior performance (Howard et al., 2017; Ng et al., 2012). These findings support the application of autonomous motivation to HPV vaccination behavior. Moreover, these findings clarify the pathways linking autonomous motivation to intentions to vaccinate.

Autonomous motivation was associated with HPV vaccine initiation; with increases in autonomous motivation, individuals had 2.5 times greater odds of receiving one or more doses of the vaccine. Moreover, greater autonomous motivation was associated with increased odds of three-dose coverage. I also conducted analyses investigating the impact of a different definition of completion (i.e., up-to-date coverage). I found the influence of autonomous motivation was less apparent when this less stringent definition of completion was applied. Given the modest effect of autonomous motivation on three-dose coverage, this decreased effect with a less stringent definition of completion is likely related to an increase in “noise” in the relationship after recording those who received only two doses but met the ACIP guidelines as having "completed" the vaccine series (*N*=3). This may have resulted from lower levels of autonomous motivation among these parents relative to parents who received all three doses of the vaccine for their children. However, despite the lack of statistically significant influence of autonomous motivation on up-to-date coverage, across both models of completion (i.e., three-dose coverage and up-to-date coverage), increases in autonomous motivation were associated with nearly doubled odds of completing the vaccine series.

Despite the mixed results for completion, examination of ordinal regression models provides a clearer picture of the overall effect of autonomous motivation across doses. The effect of autonomous motivation was consistent at each threshold between doses (e.g., receipt of dose two following receipt of dose one and receipt of dose three following receipt of the first two doses) and results indicated higher autonomous motivation was associated with 2.5 times greater likelihood of parents electing to pursue HPV vaccine completion. Thus, with each unit-increase in autonomous motivation, parents were more likely to get their child the vaccine (across all doses). Such analyses are not standard in the vaccination literature, where standard practice is to examine logistic regression models. However, application of an ordinal regression model provided an estimate of the overall influence of autonomous motivation on decisions to vaccinate.

Collectively, these findings strongly suggest that autonomous motivation is a vital factor in decisions to initiate and complete the vaccine series. A recent meta-analysis stressed the distinction between quality and quantity of motivation (Howard, Gagné, & Bureau, 2017). The authors highlighted the importance of having autonomous reasons for engaging in the behavior, rather than having a higher amount of overall motivation (e.g., the amount of both controlled and autonomous motivation). These results support this distinction and suggest only autonomous motivation was predictive of vaccination behavior.

Analyses also revealed differences in vaccination rates by sociodemographic characteristics. Results of descriptive analyses of the sample showed that younger adolescents were more likely to have initiated the vaccine series than older adolescents. Moreover, there was a trend to suggest females were more likely to meet criteria for one-dose coverage than males. Findings that younger adolescents and females are more likely to be vaccinated are consistent with previous studies (Bhatta & Phillips, 2015; Cowburn et al., 2014; Klosky et al., 2015; Rahman et al., 2015) and suggest that efforts to promote catch-up vaccination (vaccination after the target years of 11-12) among males and females, and vaccination more broadly among males, are necessary. Notably, vaccine recommendations typically focus on younger adolescents and preteens. Many parents indicate that they wish to wait to vaccinate until their child is older, but providers may fail to follow up with parents in later years, and older adolescents may have greater influence and input in the decision to obtain the vaccine than preteens. Furthermore, low vaccination rates among males may be related to the initial recommendations and marketing for the vaccine, which targeted females and highlighted benefits of the vaccine for female health (i.e., cervical cancer protection) and failed to discuss the benefits for males.

The sample consisted of parents and adolescents treated at safety-net clinics. Consequently, the majority of the sample consisted of racial and ethnic minority parents with low education and low literacy. Additionally, more than half of the sample was Spanish-speaking. Previous work examining HPV vaccination has found that vaccination rates are lowest among minority adolescents (Holman et al., 2014). Among this sample, Spanish-speaking parents had higher autonomous motivation and were more likely to vaccinate their children than English-speaking parents. This finding is consistent with previous work showing Hispanic girls living in predominantly Hispanic communities had higher rates of HPV vaccine initiation compared to Hispanic girls living in majority Non-Hispanic White or Black communities (Henry et al., 2016). Additionally, past HPV vaccine studies have shown differences in vaccination rates between Spanish-speakers and English-speakers (Baldwin, Bruce, & Tiro, 2013; Stevens et al., 2013). Previous work examining differential vaccination rates suggests that Hispanic individuals with lower levels of acculturation are more supportive of vaccination for children than individuals from other groups (Anderson et al. 1997, Henry et al., 2016). Some literature suggests these differences may be due to a lower sense of parental responsibility for vaccination among more highly acculturated parents (Prislin et al., 1998). For parents with a lower sense of parental responsibility, autonomy-supportive communication may address may be beneficial in eliciting more salient parental values and supporting more autonomously motivating perspectives (Williams et al., 2006).

The present study also compared competing hypotheses for the paths by which autonomous motivation influences intentions to vaccinate and vaccination behavior. This competitive testing strategy was selected as it would allow for the comparison of areas where Self-Determination Theory and the Integrated Behavior Change model differ in their predictions regarding the role of autonomous motivation and its specific mechanisms of action on behavior. While Self-Determination Theory suggests a direct effect of autonomous motivation on behavior, the Integrated Behavior Change model purports only indirect effects of autonomous motivation on both intentions and behavior. Findings supported the presence of both direct and indirect pathways between autonomous motivation and intentions to vaccinate suggesting that one mechanism by which autonomous motivation impacts behavior may be via intentions. Contrary to the IBC model, rather than indirect effects of autonomous motivation via attitudes, norms, and self-efficacy, only an indirect effect through attitudes was evident. Additionally, while autonomous motivation was related to both self-efficacy and subjective norms I found that self-efficacy and norms were not associated with intentions to vaccinate. This finding contrasts with previous work suggesting positive associations between self-efficacy, norms, and intentions (Gerend & Shepherd, 2012). This may be due to measurement issues as both self-efficacy and subjective norms demonstrated the lowest reliability of all measures (α=.71 for both constructs). Alternatively, the lack of significant associations between self-efficacy, norms, and intentions may be related to the sample of undecided parents. Among parents who are ambivalent about the vaccine, there may be less reliable relationships between perceptions of ability to get the vaccine, the perceived importance of others' opinions on vaccination, and intentions to vaccinate. Parents' perceptions around the opinions of others and their own ability to get the vaccine may be less established or less meaningful in the context of ambivalence. In broader samples that include parents at all levels of vaccine decision-making, self-efficacy and norms might demonstrate significant associations with intentions to vaccinate, the indirect effects through self-efficacy and norms proposed in the IBC model could be evident. Collectively, results suggest that autonomous motivation is an essential predictor of intentions to vaccinate and consideration of autonomous motivation in the context of its effects on attitudes and intentions may be beneficial. While findings of both direct and indirect effects of autonomous motivation on intentions contrast with the predictions of the Integrated Behavior Change model, the implications suggest that intervening to increase autonomous motivation may be a feasible method of changing attitudes and increasing intentions to vaccinate. Future research should clarify the presence of indirect effects through self-efficacy and norms using more reliable measures and tests interventions targeting autonomous motivation as a means of promoting vaccination by changing attitudes about vaccination.

The paths by which autonomous motivation influence vaccination behavior remain unclear. Low power compromised model estimation examining the effects of autonomous motivation on vaccination behavior and these models were not interpreted at this time. While WLMSV is considered the best estimator for models with dichotomous outcomes, it is less efficient than maximum likelihood estimation, uses pairwise deletion, and typically requires larger sample sizes than models estimated with maximum likelihood (Bandalos, 2014). Thus, in addition to low power, missing data across predictors potentially impacted ability to estimate the model successfully. Given the paucity of studies examining the influence of autonomous motivation on vaccination behavior, future studies with larger sample sizes should test the direct paths between autonomous motivation and vaccination behavior to elucidate the mechanisms by which autonomous motivation influences vaccination. The potential presence of a direct effect of autonomous motivation on behavior highlights the importance of identifying interventions to increase autonomous motivation.

Self-Determination Theory suggests that internalization of values is the mechanism of change for humans (Ryan & Deci, 1985; Williams et al., 2006). SDT-guided interventions have proven effective in increasing performance of other health behaviors that require repeated behavior performance (Williams et al., 2006). While such interventions have not been tested in the context of HPV vaccination, these findings support the utility of SDT-guided interventions to promote HPV vaccination.

Prior work to increase autonomous motivation for health outcomes has targeted autonomy support to facilitate autonomous motivation and competence (Ryan, Patrick, Deci, & Williams, 2008; Williams et al., 2006; Williams, Cox, et al., 1999; Williams & Deci, 2001; Williams et al., 1996; Williams et al., 1998). Autonomy support involves providing relevant information and soliciting choice, eliciting peoples' perspectives, and minimizing pressure (Williams et al., 2006). Thus, developing interventions targeting doctor's recommendations may be a useful means of intervening to increase autonomous motivation.

Doctor's recommendation is frequently cited as a critical predictor of vaccination (Bhatta & Phillips, 2015; Gilkey et al., 2016; Holman et al., 2014; Klosky et al., 2015). Currently, the CDC recommends "presumptive" provider recommendations for the HPV vaccine—assuming parents will decide in favor of vaccination—rather than participatory recommendations that allow for leeway (Opel et al. 2013; Shay et al. 2016). For some parents, however, a presumptive recommendation is not sufficient due to ambivalence or concerns about the vaccine. For these parents, an autonomy-supportive recommendation may be better suited to the promotion of decisions to vaccinate. Efforts to increase patient-centered care and autonomy-supportive recommendations may lead to increased autonomous motivation and vaccination behavior by acknowledging and addressing parents' concerns and priorities for their children's health. Use of an autonomy-supportive approach would also highlight the benefits of the vaccine, and thus foster autonomous motivation by helping parents understand the importance of the vaccine.

Motivational interviewing (MI) also holds promise as a means of facilitating autonomous motivation among parents who remain ambivalent after receiving a recommendation. Motivational interviewing was initially developed in the addiction treatment field as a means of facilitating health behavior performance and is a style of communication that emphasizes reflective listening, eliciting change talk, and shared decision-making (Rollnick, Miller, & Butler, 2008). The goal of motivational interviewing is often to work through ambivalence or resistance to behavior and MI has been applied to the promotion of several health behaviors (Dunn, Deroo, & Rivara, 2001). A recent intervention targeting provider communication supported the implementation of motivational interviewing with parents who were resistant to the vaccine and showed significantly higher HPV vaccine series initiation and completion (Dempsey et al., 2018). Future studies should build on these findings and develop interventions targeting parental motivation through autonomy-supportive communication styles and provision of information targeted to parents' concerns.

This study has several strengths. First, this data was longitudinal and allowed for the examination of the association between baseline motivation and subsequent vaccination behavior. Additionally, though the majority of studies on HPV vaccination behavior focus on initiation, with longitudinal data, I was able to examine completion of the vaccine series. Moreover, the use of structural equation modeling for competitive hypothesis testing facilitated a more stringent estimation of effects as well as the isolation of competing arguments (i.e., indirect vs. direct pathways from autonomous motivation to intentions to vaccinate; Brewer & Gilkey, 2012). To date, competitive hypothesis testing has not been applied to the pathways linking autonomous motivation to intentions and behavior as proposed in the Integrated Behavior Change model (Hagger & Chatzisarantis, 2009; 2014). However, this method holds promise for enhancing understanding of the mechanisms of change for autonomous motivation and the advancement of theory.

This study does have some limitations. First, the sample was restricted to parents who had never heard of the HPV vaccine or were undecided about vaccination. This limits generalizability of these findings as parents who had decided for, or against, the vaccine were excluded. For parents who had already decided to vaccinate their adolescents, we might expect to see high levels of autonomous motivation. For parents who previously decided *not* to vaccinate their children, however, the underlying motivations are less predictable. For example, parents with negative perceptions about the HPV vaccine may report low levels of all types of motivation. Alternatively, parents with negative perceptions of the vaccine may be autonomously motivated against vaccination. Understanding the motivation underlying decisions not to vaccinate may be beneficial in promoting vaccination among parents who are ambivalent or resistant to vaccination. A related limitation of this study is the lack data on parental vaccine hesitancy and amotivation. According to Self-Determination Theory, amotivation is the lack of motivation to perform a behavior (Levesque et al., 2007). For some parents, amotivation and hesitancy may lead to decisions to delay the vaccine series until their child is older. Future studies should examine parents at all stages of decision-making and assess amotivation and vaccine hesitancy to understand how these constructs relate to refusal and delay of the vaccine. A further limitation of the study was the relatively small sample size, which was problematic in structural equation models examining one-dose coverage where sample size suggestions range from 200-500 when using a WLMSV estimator for dichotomous outcomes (Bandalos, 2014). Future research should examine direct and indirect pathways in larger samples that may allow for more accurate estimation of effects. Moreover, the relatively short time frame for follow up (i.e., twelve months) was a limitation of this study. While the twelve-month time frame can be considered sufficient for completion based on the recommended vaccine schedule, few parents are sticking to this timeline. Practically, the majority of parents vaccinate their children during their annual, well-child visits (Dempsey et al., 2018; Dempsey, Abraham, Dalton, & Ruffin, 2009). Moreover, there is no evidence to suggest that completion on the recommended schedule is needed to maintain efficacy of the vaccine, so there is little incentive for parents or providers to adhere to the recommended dosing schedule. Examination of the overall rates of vaccination in Dallas County for 2016 reveals they are higher than rates in this study population (45.7% of adolescents had one-dose coverage, and 23.9% of adolescents had up-to-date coverage in 2016; Walker et al., 2017) and suggest that with more time, rates of adolescent vaccination would likely continue to rise. Thus, it is likely that with increased time for follow-up (e.g., two years) I would see an increased frequency of completion, and a stronger influence of autonomous motivation.

Although I had temporal precedence of behavior, all predictors were measured at the same time and are correlational. This limits the ability to draw conclusions about the indirect versus direct effects of autonomous motivation on intentions. A future study assessing the indirect and direct effects of autonomous motivation on intentions measured at a later time or on behavior would provide a better estimation of these effects (Maxwell, Cole, & Mitchell, 2011). Finally, the sample consists of individuals receiving care in safety net clinics. Low education, low health literacy, and low socioeconomic status overall characterize the sample as almost all patients seen at these clinics are under- or un-insured. It is possible that parents of higher education and SES might have other factors that impact vaccine decision-making and thus findings may not generalize to other populations.

Conclusions

These findings suggest that autonomous motivation predicts a higher likelihood of HPV vaccine coverage. Additionally, findings from this study support the concept that the quality of motivation is critical in promoting behavior as neither introjected nor external motivation showed any significant effect on vaccination behavior. Consequently, these findings support the utility of providing autonomy-supportive interventions.

Results also suggest that considering autonomous motivation in the context of attitudes toward vaccination and intentions to vaccinate may be beneficial to facilitating understanding of the mechanisms by which it impacts behavior. Autonomous motivation was found to have both a significant indirect effect via attitudes and a direct effect on intentions to vaccinate. This suggests that autonomous motivation leads to the development of more positive attitudes and influences behavior through the internalization of beliefs as posited by the Self-Determination Theory. These findings provide a foundation upon which future research can expand through the development of autonomy supportive interventions to increase HPV vaccination.

References

Ajzen, I. (1996). The directive influence of attitudes on behavior. In P. Gollwitzer & J. A. Bargh (Eds.), *Psychology of action* (pp. 385–403). New York, NY: Guilford.

Ajzen, Icek. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211.

Allen, J. D., Coronado, G. D., Williams, R. S., Glenn, B., Escoffery, C., Fernandez, M., … Mullen, P. D. (2010). A systematic review of measures used in studies of human papillomavirus (HPV) vaccine acceptability. *Vaccine*, *28*(24), 4027–4037. https://doi.org/10.1016/j.vaccine.2010.03.063

Anderson, L. M., Wood, D. L., & Sherbourne, C. D. (1997). Maternal acculturation and childhood immunization levels among children in Latino families in Los Angeles. *American Journal of Public Health*, *87*(12), 2018–2021. https://doi.org/10.2105/AJPH.87.12.2018

Arbuckle, J. L. (2010). IBM SPSS Amos 19 user's guide. *Crawfordville, FL: Amos Development Corporation*, 635.

Baldwin, A. S., Bruce, C. M., & Tiro, J. A. (2013). Understanding how mothers of adolescent girls obtain information about the human papillomavirus vaccine: Associations between mothers' health beliefs, information seeking, and vaccination intentions in an ethnically diverse sample. *Journal of Health Psychology*, *18*(7), 926–938. https://doi.org/10.1177/1359105312445078

Baldwin, Austin S., Denman, D. C., Sala, M., Marks, E. G., Shay, L. A., Fuller, S., … Tiro, J. A. (2017). Translating self-persuasion into an adolescent HPV vaccine promotion intervention for parents attending safety-net clinics. *Patient Education and Counseling*, *100*(4), 736–741. https://doi.org/10.1016/j.pec.2016.11.014

Bandalos, D. L. (2014). Relative performance of categorical diagonally weighted least squares and robust maximum likelihood estimation. *Structural Equation Modeling: A Multidisciplinary Journal*, *21*(1), 102–116. https://doi.org/10.1080/10705511.2014.859510

Bartlett, J. A., & Peterson, J. A. (2011). The uptake of human papillomavirus (HPV) vaccine among adolescent females in the United States: A review of the literature. *The Journal of School Nursing*, *27*(6), 434–446. https://doi.org/10.1177/1059840511415861

Bastani, R., Glenn, B. A., Tsui, J., Chang, L. C., Marchand, E. J., Taylor, V. M., & Singhal, R. (2011). Understanding suboptimal human papillomavirus vaccine uptake among ethnic minority girls. *Cancer Epidemiology Biomarkers & Prevention*, *20*(7), 1463–1472. https://doi.org/10.1158/1055-9965.EPI-11-0267

Bhatta, M. P., & Phillips, L. (2015). Human papillomavirus vaccine awareness, uptake, and parental and health care provider communication among 11- to 18-year-old adolescents in a rural Appalachian Ohio county in the United States: HPV vaccine uptake among Appalachian adolescents. *The Journal of Rural Health*, *31*(1), 67–75. https://doi.org/10.1111/jrh.12079

Brewer, N. T., & Gilkey, M. B. (2012). Comparing theories of health behavior using data from longitudinal studies: A comment on Gerend and Shepherd. *Annals of Behavioral Medicine*, *44*(2), 147–148. https://doi.org/10.1007/s12160-012-9396-z

Brewer, N. T., Gottlieb, S. L., Reiter, P. L., McRee, A.-L., Liddon, N., Markowitz, L., & Smith, J. S. (2011). Longitudinal predictors of human papillomavirus vaccine initiation among adolescent girls in a high-risk geographic area. *Sexually Transmitted Diseases*, *38*(3), 197–204. https://doi.org/10.1097/OLQ.0b013e3181f12dbf

Bynum, S. A., Wigfall, L. T., Brandt, H. M., Richter, D. L., Glover, S. H., & Hébert, J. R. (2013). Assessing the influence of health literacy on HIV-positive women's cervical cancer prevention knowledge and behaviors. *Journal of Cancer Education*, *28*(2), 352–356.

Chatzisarantis, N. L. D., & Hagger, M. S. (2009). Effects of an intervention based on self-determination theory on self-reported leisure-time physical activity participation. *Psychology & Health*, *24*(1), 29–48. https://doi.org/10.1080/08870440701809533

Cowburn, S., Carlson, M., Lapidus, J., Heintzman, J., Bailey, S., & DeVoe, J. (2014). Insurance continuity and human papillomavirus vaccine uptake in Oregon and California federally qualified health centers. *American Journal of Public Health*, *104*(9), e71–e79.

Deci, Edward L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology/Psychologie Canadienne*, *49*(3), 182–185. https://doi.org/10.1037/a0012801

Deci, E.L., & Ryan, R. M. (1985). The general causality orientations scale: Self-determination in personality. *Journal of Research in Personality*, *19*(2), 109–134.

Dempsey, A., Cohn, L., Dalton, V., & Ruffin, M. (2010). Patient and clinic factors associated with adolescent human papillomavirus vaccine utilization within a university-based health system. *Vaccine*, *28*(4), 989–995. https://doi.org/10.1016/j.vaccine.2009.10.133

Dempsey, A. F., Pyrznawoski, J., Lockhart, S., Barnard, J., Campagna, E. J., Garrett, K., … O'Leary, S. T. (2018). Effect of a health care professional communication training intervention on adolescent human papillomavirus vaccination: A cluster randomized clinical trial. *JAMA Pediatrics*, e180016. https://doi.org/10.1001/jamapediatrics.2018.0016

Denman, D. C., Baldwin, A. S., Marks, E. G., Lee, S. C., & Tiro, J. A. (2016). Modification and validation of the Treatment Self Regulation Questionnaire to assess parental motivation for HPV vaccination of adolescents. *Vaccine*, *34*(41), 4985–4990.

Dixon, B. E., Kasting, M. L., Wilson, S., Kulkarni, A., Zimet, G. D., & Downs, S. M. (2017). Health care providers' perceptions of use and influence of clinical decision support reminders: qualitative study following a randomized trial to improve HPV vaccination rates. *BMC Medical Informatics and Decision Making*, *17*(1). https://doi.org/10.1186/s12911-017-0521-6

Dunn, C., Deroo, L., & Rivara, F. P. (2001). The use of brief interventions adapted from motivational interviewing across behavioral domains: a systematic review. *Addiction*, *96*(12), 1725–1742. https://doi.org/10.1046/j.1360-0443.2001.961217253.x

Edmunds, J., Ntoumanis, N., & Duda, J. L. (2006). A test of self-determination theory in the exercise domain. *Journal of Applied Social Psychology*, *36*(9), 2240–2265.

Fenton, A. T., Elliott, M. N., Schwebel, D. C., Berkowitz, Z., Liddon, N. C., Tortolero, S. R., … Schuster, M. A. (2017). Unequal interactions: Examining the role of patient-centered care in reducing inequitable diffusion of a medical innovation, the human papillomavirus (HPV) vaccine. *Social Science & Medicine*. https://doi.org/10.1016/j.socscimed.2017.09.030

Fuchs, E. L., Rahman, M., & Berenson, A. B. (2016). Examining maternal beliefs and human papillomavirus vaccine uptake among male and female children in low-income families. *Papillomavirus Research*, *2*, 38–40. https://doi.org/10.1016/j.pvr.2016.02.002

Garcini, L. M., Galvan, T., & Barnack-Tavlaris, J. L. (2012). The study of human papillomavirus (HPV) vaccine uptake from a parental perspective: A systematic review of observational studies in the United States. *Vaccine*, *30*(31), 4588–4595. https://doi.org/10.1016/j.vaccine.2012.04.096

Gerend, M. A., & Barley, J. (2009). Human papillomavirus vaccine acceptability among young adult men. *Sexually Transmitted Diseases*, *36*(1), 58–62.

Gerend, M. A., & Shepherd, J. E. (2012). Predicting human papillomavirus vaccine uptake in young adult women: Comparing the health belief model and theory of planned behavior. *Annals of Behavioral Medicine*, *44*(2), 171–180.

Gilkey, M. B., Malo, T. L., Shah, P. D., Hall, M. E., & Brewer, N. T. (2015). Quality of physician communication about human papillomavirus vaccine: Findings from a national survey. *Cancer Epidemiology Biomarkers & Prevention*, *24*(11), 1673–1679. https://doi.org/10.1158/1055-9965.EPI-15-0326

Gilkey, Melissa B., Calo, W. A., Moss, J. L., Shah, P. D., Marciniak, M. W., & Brewer, N. T. (2016a). Provider communication and HPV vaccination: The impact of recommendation quality. *Vaccine*, *34*(9), 1187–1192. https://doi.org/10.1016/j.vaccine.2016.01.023

Gilkey, Melissa B., Calo, W. A., Moss, J. L., Shah, P. D., Marciniak, M. W., & Brewer, N. T. (2016b). Provider communication and HPV vaccination: The impact of recommendation quality. *Vaccine*, *34*(9), 1187–1192. https://doi.org/10.1016/j.vaccine.2016.01.023

Hagger, M. S. (2006). From psychological need satisfaction to intentional behavior: Testing a motivational sequence in two behavioral contexts. *Personality and Social Psychology Bulletin*, *32*(2), 131–148. https://doi.org/10.1177/0146167205279905

Hagger, Martin S., & Chatzisarantis, N. L. (2014). An integrated behavior change model for physical activity. *Exercise and Sport Sciences Reviews*, *42*(2), 62–69.

Hagger, Martin S., Chatzisarantis, N. L., & Biddle, S. J. (2002). The influence of autonomous and controlling motives on physical activity intentions within the Theory of Planned Behaviour. *British Journal of Health Psychology*, *7*(3), 283–297.

Hagger, Martin S., & Chatzisarantis, N. L. D. (2009). Integrating the theory of planned behaviour and self-determination theory in health behaviour: A meta-analysis. *British Journal of Health Psychology*, *14*(2), 275–302. https://doi.org/10.1348/135910708X373959

Healy, C. M., Montesinos, D. P., & Middleman, A. B. (2014). Parent and provider perspectives on immunization: Are providers overestimating parental concerns? *Vaccine*, *32*(5), 579–584. https://doi.org/10.1016/j.vaccine.2013.11.076

Henry, K. A., Stroup, A. M., Warner, E. L., & Kepka, D. (2016). Geographic factors and human papillomavirus (HPV) vaccination initiation among adolescent girls in the United States. *Cancer Epidemiology Biomarkers & Prevention*, *25*(2), 309–317. https://doi.org/10.1158/1055-9965.EPI-15-0658

Holman, D. M., Benard, V., Roland, K. B., Watson, M., Liddon, N., & Stokley, S. (2014). Barriers to human papillomavirus vaccination among US adolescents: A systematic review of the literature. *JAMA Pediatrics*, *168*(1), 76. https://doi.org/10.1001/jamapediatrics.2013.2752

Howard, J. L., Gagné, M., & Bureau, J. S. (2017). Testing a continuum structure of self-determined motivation: A meta-analysis. *Psychological Bulletin*, *143*(12), 1346–1377. https://doi.org/10.1037/bul0000125

Kennedy, S., Goggin, K., & Nollen, N. (2004). Adherence to HIV medications: Utility of the theory of self-determination. *Cognitive Therapy and Research*, *28*(5), 611–628.

Kessels, S. J. M., Marshall, H. S., Watson, M., Braunack-Mayer, A. J., Reuzel, R., & Tooher, R. L. (2012). Factors associated with HPV vaccine uptake in teenage girls: A systematic review. *Vaccine*, *30*(24), 3546–3556. https://doi.org/10.1016/j.vaccine.2012.03.063

Kinnafick, F.-E., Thogersen-Ntoumani, C., & Duda, J. L. (2014). Physical activity adoption to adherence, lapse, and dropout: A self-determination theory perspective. *Qualitative Health Research*, *24*(5), 706–718. https://doi.org/10.1177/1049732314528811

Kline, R. B. (2016). *Principles and Practices of Structural Equation Modeling* (4th ed.). New York, NY: Guilford Press.

Klosky, J. L., Russell, K. M., Simmons, J. L., Foster, R. H., Peck, K., Green, D. M., & Hudson, M. M. (2015). Medical and sociodemographic factors associated with human papillomavirus (HPV) vaccination adherence among female survivors of childhood cancer: HPV vaccination in cancer survivors. *Pediatric Blood & Cancer*, *62*(9), 1630–1636. https://doi.org/10.1002/pbc.25539

Kornides, M. L., McRee, A.-L., & Gilkey, M. B. (2018). Parents who decline HPV vaccination: Who later accepts and why? *Academic Pediatrics*, *18*(2), S37–S43. https://doi.org/10.1016/j.acap.2017.06.008

Kouyoumdjian, F. G., & Bailowitz, A. (2011). Completion of the human papillomavirus vaccine series in females attending an urban immunization clinic. *The Pediatric Infectious Disease Journal*, *30*(8), 718–719.

Levesque, C. S., Williams, G. C., Elliot, D., Pickering, M. A., Bodenhamer, B., & Finley, P. J. (2007). Validating the theoretical structure of the Treatment Self-Regulation

Questionnaire (TSRQ) across three different health behaviors. *Health Education Research*, *22*(5), 691–702.

Maxwell, S. E., Cole, D. A., & Mitchell, M. A. (2011). Bias in cross-sectional analyses of longitudinal mediation: partial and complete mediation under an autoregressive model. *Multivariate Behavioral Research*, *46*(5), 816–841. https://doi.org/10.1080/00273171.2011.606716

McLachlan, S., & Hagger, M. S. (2011). The influence of chronically accessible autonomous and controlling motives on physical activity within an extended theory of planned behavior. *Journal of Applied Social Psychology*, *41*(2), 445–470.

Muthén, L.K. and Muthén, B.O. (1998-2017). Mplus User's Guide. Eighth Edition. Los Angeles, CA: Muthén & Muthén

Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. (2012). Self-determination theory applied to health contexts: A meta-analysis. *Perspectives on Psychological Science*, *7*(4), 325–340. https://doi.org/10.1177/1745691612447309

Norman, P., & Conner, M. (2005). The theory of planned behavior and exercise: Evidence for the mediating and moderating roles of planning on intention-behavior relationships. *Journal of Sport and Exercise Psychology*, *27*(4), 488–504.

Opel, D. J., Heritage, J., Taylor, J. A., Mangione-Smith, R., Salas, H. S., DeVere, V., … Robinson, J. D. (2013). The Architecture of Provider-Parent Vaccine Discussions at Health Supervision Visits. *PEDIATRICS*, *132*(6), 1037–1046. https://doi.org/10.1542/peds.2013-2037

Prislin, R., Suarez, L., Simpson, D. M., & Dyer, J. A. (1998). When acculturation hurts: the case of immunization. *Social Science & Medicine*, *47*(12), 1947–1956.

Rahman, M., Islam, M., & Berenson, A. B. (2015). Differences in HPV immunization levels among young adults in various regions of the United States. *Journal of Community Health*, *40*(3), 404–408. https://doi.org/10.1007/s10900-015-9995-2

Raykov, T., & Marcoulides, G. A. (1999). On desirability of parsimony in structural equation model selection. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(3), 292–300. https://doi.org/10.1080/10705519909540135

Robinson, C. L., Romero, J. R., Kempe, A., Pellegrini, C., & Szilagyi, P. (2018). Advisory Committee on Immunization Practices recommended immunization schedule for children and adolescents aged 18 years or younger — United States, 2018, *67*(5), 156-157.

Rollnick, S., Miller, W., & Butler, C., C. (2008). *Motivational Interviewing in Health Care: Helping Patients Change Behavior*. New York, NY: Guilford Press.

Ryan, Richard M., Patrick, H., Deci, E. L., & Williams, G. C. (2008). Facilitating health behaviour change and its maintenance: Interventions based on self-determination theory. *European Health Psychologist*, *10*(1), 2–5.

Ryan, R.M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68–78.

Shay, L. A., Street, R. L., Baldwin, A. S., Marks, E. G., Lee, S. C., Higashi, R. T., … Tiro, J. A. (2016). Characterizing safety-net providers' HPV vaccine recommendations to undecided parents: A pilot study. *Patient Education and Counseling*, *99*(9), 1452–1460. https://doi.org/10.1016/j.pec.2016.06.027

Sheeran, P., & Abraham, C. (2003). Mediator of moderators: Temporal stability of intention and the intention-behavior relation. *Personality and Social Psychology Bulletin*, *29*(2), 205–215.

Standage, M., Sebire, S. J., Loney, T., & others. (2008). Does exercise motivation predict engagement in objectively assessed bouts of moderate-intensity exercise?: A self-determination theory perspective. *Journal of Sport & Exercise Psychology*, *30*(4), 337.

Stevens, C. F., Caughy, M. O., Lee, S. C., Bishop, W. P., & Tiro, J. A. (2013). Does language moderate the influence of information scanning and seeking on HPV knowledge and vaccine awareness and initiation among Hispanics? *Ethnicity & Disease*, *23*(1), 95–102.

Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 9*(28), 1-30.

Thomas, T. L., Strickland, O., Diclemente, R., & Higgins, M. (2013). An opportunity for cancer prevention during preadolescence and adolescence: Stopping human papillomavirus (HPV)-related cancer through HPV vaccination. *Journal of Adolescent Health*, *52*(5), S60–S68. https://doi.org/10.1016/j.jadohealth.2012.08.011

Tiro, J. A., Lee, S. C., Marks, E. G., Persaud, D., Skinner, C. S., Street, R. L., … Baldwin, A.S. (2016). Developing a tablet-based self-persuasion intervention promoting adolescent HPV vaccination: Protocol for a three-stage mixed-methods study. *JMIR Research Protocols*, *5*(1).

Walker, T. Y., Elam-Evans, L. D., Singleton, J. A., Yankey, D., Markowitz, L. E., Fredua, B., … Stokley, S. (2017). National, Regional, State, and Selected Local Area Vaccination Coverage Among Adolescents Aged 13–17 Years — United States, 2016, *66*(33), 9.

Widdice, L. E., Bernstein, D. I., Leonard, A. C., Marsolo, K. A., & Kahn, J. A. (2011). Adherence to the HPV vaccine dosing intervals and factors associated with completion of 3 doses. *Pediatrics*, *127*(1), 77–84. https://doi.org/10.1542/peds.2010-0812

Williams, G. C., Patrick, H., Niemiec, C. P., Williams, L. K., Divine, G., Lafata, J. E., … Pladevall, M. (2009). Reducing the health risks of diabetes: How self-determination theory may help improve medication adherence and quality of life. *The Diabetes Educator*, *35*(3), 484–492. https://doi.org/10.1177/0145721709333856

Table 1. Participant Characteristics

	Mean (SD)	Range
Autonomous Motivation	4.11 (.57)	2-5
Introjected Motivation	2.93 (1.09)	1-5
External Motivation	1.97 (.72)	1-4.5
	N	%
Vaccination Rates		
One-Dose Coverage	65	36.7
Three-Dose Coverage	27	15.3
Up-To-Date Coverage	30	16.9
Parent Sex		
Female	172	97.2
Male	5	2.8
Parent Language		
Spanish	104	58.8
English	73	41.2
Parent Age		
20-29	3	1.7
30-39	96	54.2
40-49	60	33.9
50 or older	18	10.2
Parent Race/Ethnicity		
Hispanic	122	68.9
Non-Hispanic Black	50	28.2
Non-Hispanic White	4	2.3
Unknown race/ethnicity	1	0.6
Parent Education		
Less than high school	37	20.9
Some high school	37	20.9
High school/Vocational degree	61	34.5
Some college/College graduate	42	23.7
Adolescent Sex		
Male	93	52.5
Female	84	47.5
Adolescent Age		
11-12	88	49.7
13-14	47	26.6
15-17	42	23.7
Adolescent Race/Ethnicity		
Hispanic	119	67.2
Non-Hispanic Black	48	27.1
Non-Hispanic White	4	2.3
Unknown race/ethnicity	6	3.4

*Survey responses ranged from (1) *strongly disagree* to (5) *strongly agree*, thus higher values represent higher motivation.

Table 2. Factor Loadings Across All Latent Constructs

Construct	**Loading**	***p***
Autonomous Motivation (α=.82)		
The reason you would get [child's name here] the vaccine is because you want to take responsibility for your child's health.	.546	<.001
The reason you would get [child's name here] the vaccine is because it is important.	.823	<.001
The reason you would get [child's name here] the vaccine is because it is consistent with your goals as a parent.	.723	<.001
The reason you would get [child's name here] the vaccine is because you believe it is the best thing for your child.	.814	<.001
Introjected Motivation (α=.75)		
The reason you would get [child's name here] the vaccine is because you would feel guilty or ashamed if you did NOT.	.75	<.001
The reason you would get [child's name here] the vaccine is because you would feel bad about yourself if you did NOT.	.80	<.001
External Motivation (α=.79)		
The reason you would get [child's name here] the vaccine is because others would be upset with you if you did NOT.	.82	<.001
The reason you would get [child's name here] the vaccine is because you feel pressure from others to do so.	.81	<.001
Intentions (α=.87)		
In the next year, how likely is it that you will think about getting the HPV vaccine for [child's name here]?	.744	<.001
In the next year, how likely is it that you will get the HPV vaccine for [child's name here]?	.878	<.001
In the next year, if a doctor or nurse at the clinic recommends the HPV vaccine for [child's name here], how likely is it that you would get [child's name here] the vaccine?	.829	<.001
Self-Efficacy (α=.71)		
You are confident that you can get the HPV vaccine for [child's name here].	.735	<.001
You are confident that you can get the HPV vaccine for [child's name here], even if it means going to the clinic three times.	.759	<.001

Attitudes (α=.81)		
Getting my child the HPV vaccine will be good for my child's health.	.803	<.001
Other parents in my community are getting their children the HPV vaccine.	.382	<.001
Getting the HPV vaccine could save my child's life.	.705	<.001
The HPV vaccine was well tested before being made available to the public.	.664	<.001
The benefits of having my child get the HPV vaccine are greater than the risks related to getting the vaccine.	.577	<.001
Getting the HPV vaccine will give me peace of mind about my child's health.	.779	<.001
Norms (α=.71)		
Your spouse or partner influences your decision about getting [child's name here] the HPV vaccine.	.668	<.001
Your family influences your decision about getting [child's name here] the HPV vaccine.	.660	<.001
Your friends influence your decision about getting [child's name here] the HPV vaccine.	.402	<.001
Your child's doctor or nurse influences your decision about getting [child's name here] the HPV vaccine.	.524	<.001

Table 3. Logistic Regression Models

Model	B	S.E.	Wald	*p*	Exp(B)	CI 95%
Motivation Predicting One-Dose Coverage						
Autonomous Motivation	.866	.411	4.442	.035	2.378	1.063 - 5.320
Introjected Motivation	.197	.186	1.125	.289	1.218	.846 - 1.752
External Motivation	.019	.280	.005	.945	1.020	.589 - 1.765
Motivation Predicting Three-Dose Coverage						
Autonomous Motivation	1.310	.607	4.655	.031	3.706	1.127 - 12.182
Introjected Motivation	.124	.255	.237	.626	1.132	.687 - 1.868
External Motivation	.557	.368	2.295	.130	1.745	.849 - 3.587
Motivation Predicting Up-To-Date Coverage						
Autonomous Motivation	.834	.544	2.349	.125	2.302	.793 - 6.687
Introjected Motivation	.136	.245	.308	.579	1.146	.708 - 1.853
External Motivation	.372	.360	1.066	.302	1.450	.716 – 2.93

*All regression models controlled for recruitment arm, adolescent age, adolescent sex, and parent preferred language.

Table 4. Ordinal Regression Models

Model	B	S.E.	Wald	*p*	Exp(B)	CI 95%
Autonomous Motivation						
	.988	.403	6.014	.014	2.686	1.219 - 5.918
Introjected Motivation						
	.168	.176	.908	.341	1.183	.837 - 1.671
External Motivation						
	.223	.264	.715	.398	1.250	.745 - 2.098

*All regression models controlled for recruitment arm, adolescent age, adolescent sex, and parent preferred language.

Table 5. Bivariate Correlations between Latent Variables

Construct	Attitudes	Self-Efficacy	Norms	Intentions	Autonomous Motivation
Attitudes	1				
Self-Efficacy	.262**	1			
Norms	.110	.146	1		
Intentions	.495**	.138	.033	1	
Autonomous Motivation	.612**	.234**	.082	.516**	1

Table 6. Fit indices for competitive model testing

Model	χ^2	*df*	CFI	RMSEA	CI 90%
Direct & Indirect Paths	223.101	140	.935	.058	.043 - .072
Direct Path Only	309.295	143	.869	.081	.069 - .093
Indirect Paths Only	229. 798	141	.930	.060	.045 - .073

Model Comparison	χ^2 difference	*df* difference	Significance testing
Direct & Indirect Paths vs, Direct Path Only	86.194	3	p= .000
Direct & Indirect Paths vs. Indirect Paths Only	6.697	1	p= .009

Figure 1. Proposed Model with Direct and Indirect Effects for Research Question 3

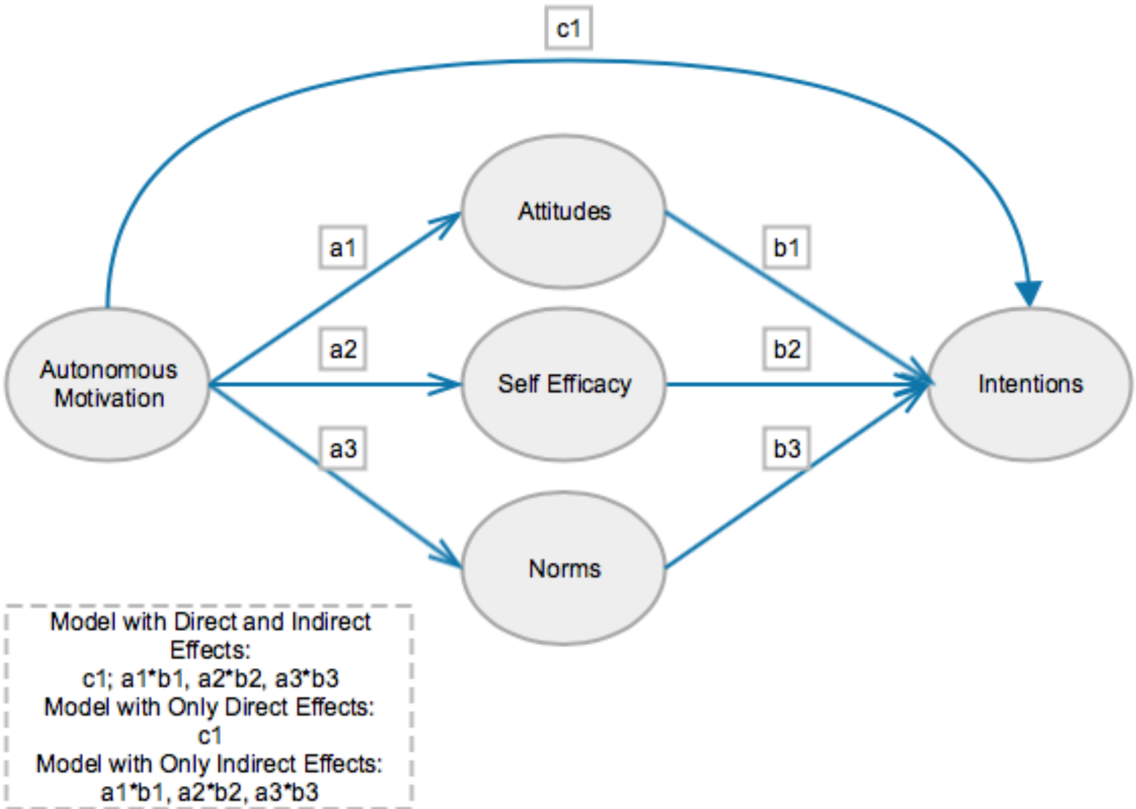


Figure 2. Proposed Model with Direct and Indirect Effects for Research Question 4

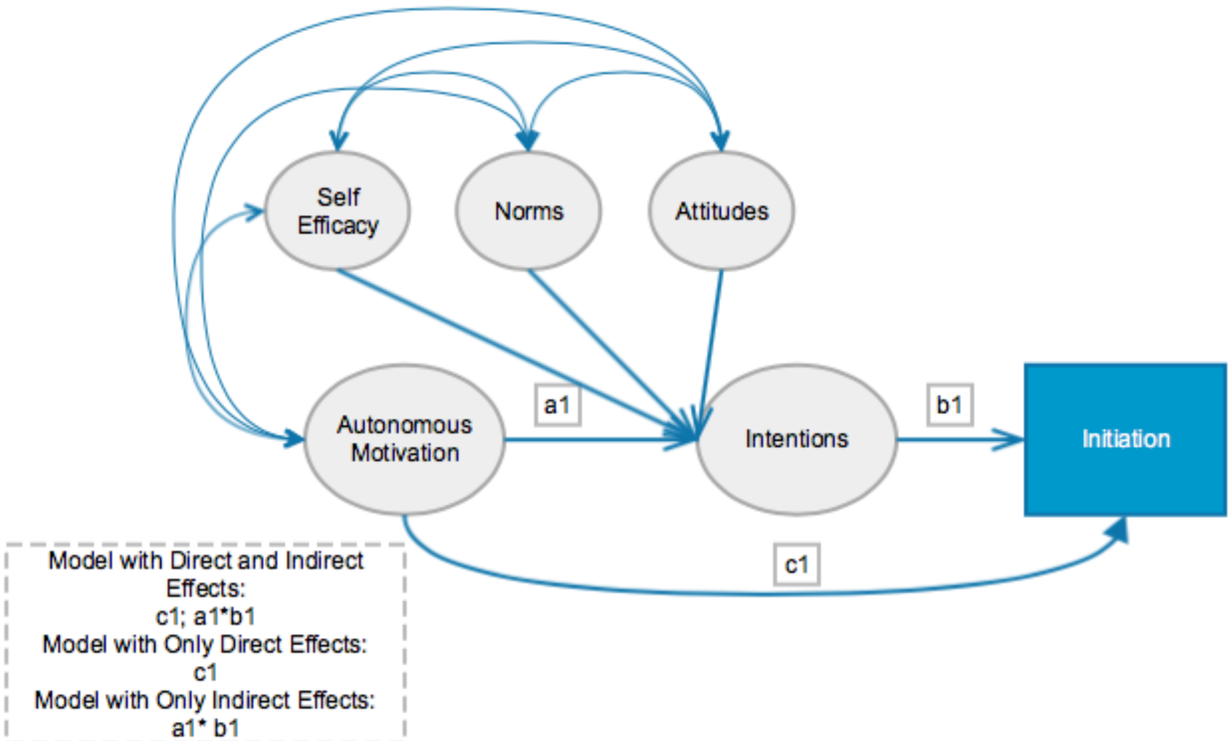
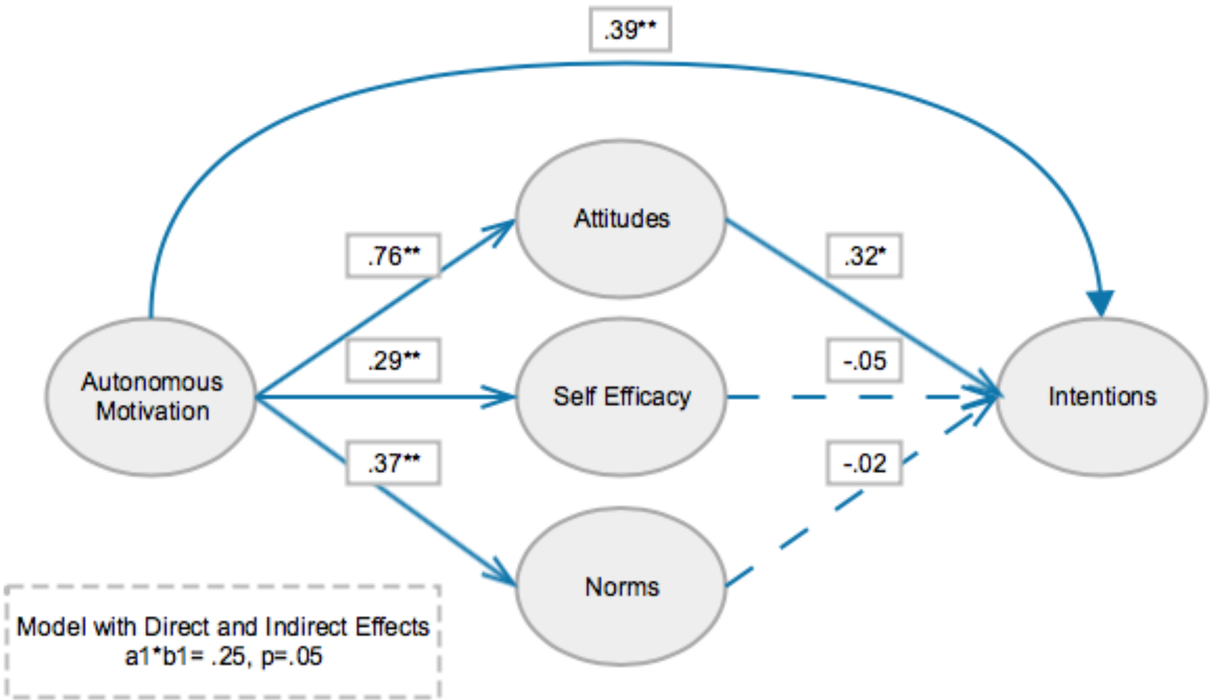
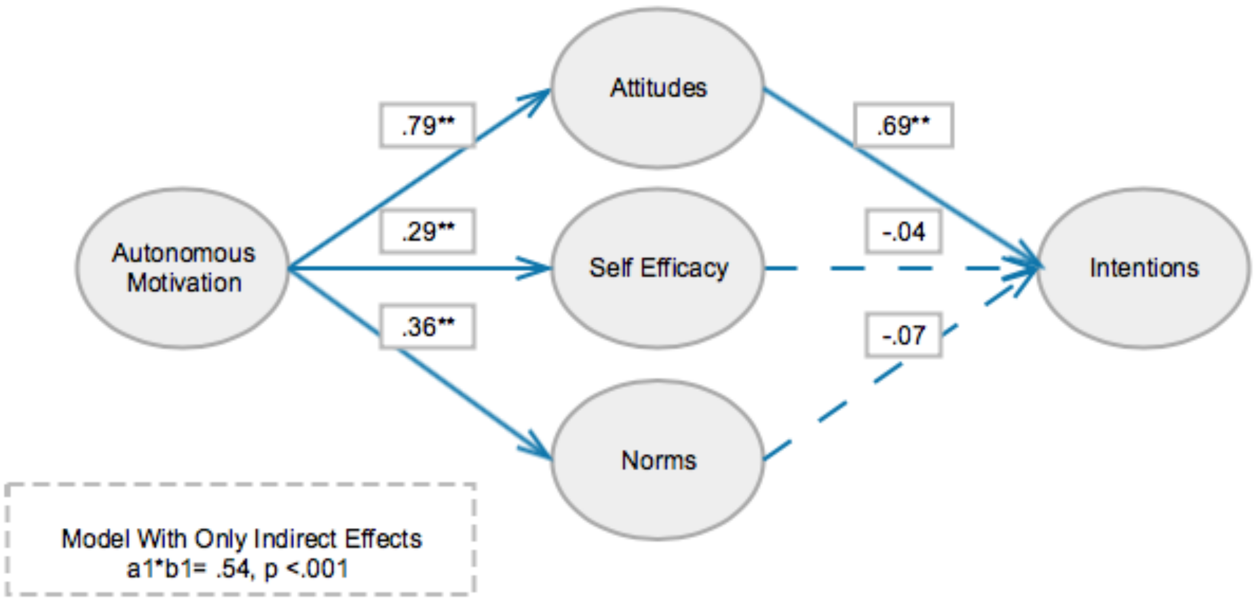


Figure 3. Final Model with Direct and Indirect Effects for Research Question 3



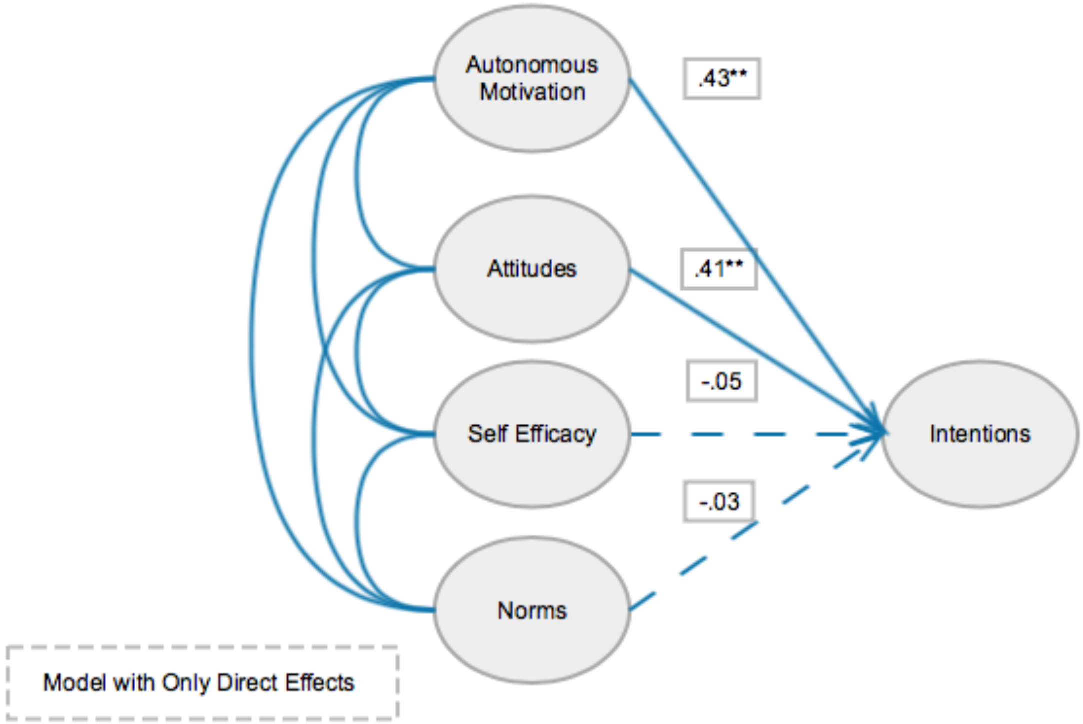
Dashed lines represent nonsignificant paths. *Solid lines* represent significant paths.
**p* $\leq$ .05, ** *p* $\leq$.001

Supplemental Figure 1. Final Model with only Indirect Effects



Dashed lines represent nonsignificant paths. *Solid lines* represent significant paths.
* $p \leq .05$, ** $p \leq .001$

Supplemental Figure 2. Final Model with only Direct Effects



Dashed lines represent nonsignificant paths. *Solid lines* represent significant paths.
**p* ≤ .05, ** *p* ≤.001