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Group-based trajectories and predictors of adherence to physical distancing during the COVID-19 pandemic

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ABSTRACT

Objective: This study sought to identify psychosocial predictors of trajectories of adherence to physical distancing alongside changes in public health measures during the COVID-19 pandemic. **Design:** A three-time point longitudinal survey during the first two waves of the COVID-19 pandemic. **Methods:** Participants (N = 1003) completed self-report measures of adherence to physical distancing over an 8-month period at the start (T1) and end (T2) of the first wave of the pandemic, and the start of the second wave of the pandemic (T3). Participants also completed measures of their health beliefs related to the self and others, social norms, emotional distress, and sociodemographic characteristics. **Results:** Using group-based trajectory modeling, four trajectories of adherence to physical distancing emerged: a high-adherence trajectory, a slow-declining trajectory, a fluctuating trajectory, and a fast-declining trajectory. The most important psychosocial predictors of poorer adherence trajectories included perceptions of lower self-efficacy and higher barriers to adherence, as well as lower prosocial attitudes towards physical distancing. **Conclusion:** Public health messages targeting these factors may be most relevant to promote sustained adherence to physical distancing over time in the context of a pandemic.

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COVID-19; adherence; physical distancing; health beliefs; social norms

In response to the COVID-19 pandemic, many governments around the world imposed public health measures to limit physical proximity among individuals and reduce person-to-person transmission of the SARS-CoV-2 coronavirus. Population-level measures such as large-scale lockdowns to restrict movement and mass gatherings were shown to be effective at curbing infection rate, reducing pressure on health care systems, and preventing death (Hale et al., 2021). Yet, these were not feasible measures for long-term management of the pandemic due to their negative economic and social consequences (Bonaccorsi et al., 2020). In addition to these population-level

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measures, governments also provided individual-level physical distancing recommendations, given that personal preventive practices, along with other public health strategies (e.g., mask wearing, ventilation), were critical for managing the pandemic pending the availability of vaccines (Michie & West, 2021).

At the start of the pandemic, individual-level physical distancing recommendations globally included indications to stay home, minimise non-essential travel, avoid private or public social gatherings, and maintain a two-meter distance from others in public (Han et al., 2020). Cross-sectional research shows that adherence to individual-level physical distancing measures during the first wave of the pandemic was generally high in most countries. For example, one study across seven European countries demonstrated that approximately 90% of respondents in each country reported being 'fully' or 'quite strongly' adherent to maintaining a minimum one-meter physical distance from others (Varghese et al., 2021). Similar patterns of high adherence to the various physical distancing recommendations have been self-reported on all continents (e.g. Al-Hasan et al., 2020; Gouin et al., 2021; Hagger et al., 2021; Majam et al., 2021; Pollak et al., 2021).

Despite high initial adherence rates, most longitudinal studies to date have reported declining adherence to local physical distancing recommendations during the first wave of the pandemic (Tam et al., 2021; Wright et al., 2021). However, a multi-country study spanning nine months found a U-shaped change in adherence over time, with decreases in physical distancing over the first six months followed by a re-uptake of these behaviours, although to a lesser extent, potentially due to new pandemic waves (Petherick et al., 2021). More research with longer follow-ups is required to describe how adherence evolves as populations cycle through pandemic waves.

Prior longitudinal studies have focused on describing average levels of adherence over time. Yet, important between-person variability is observed within these longitudinal studies. Between-person variability offers explanations for differences in both initial adherence and the rate of decline over time, usually as a function of sociodemographic, cognitive, personality, and emotional factors (Petherick et al., 2021; Wright et al., 2021). Also, geo-localisation data suggest significant between-person variance in adherence to physical distancing within countries and local communities (Ingram et al., 2021). These findings suggest that subgroups of individuals may be less adherent to physical distancing over time. Identifying predictors of adherence and non-adherence is needed to develop tailored interventions targeting subgroups of the population that may be less adherent (Webster et al., 2020). A recent review of the research on predictors to physical distancing has also outlined how few studies to date have used theory-based predictors (Noone et al., 2021). To address these limitations, the current study focused on identifying subgroups of individuals with different trajectories of adherence over time and identifying theory-based factors that may predict physical distancing.

The health belief model (HBM) (Rosenstock, 1974) outlines five factors that may influence behaviour change such as adherence to physical distancing. Specifically, the HBM posits that, when presented with a stimulus to enact a preventive health behaviour (i.e. cue-to-action), individuals who are most likely to engage in the behaviour will: (a) perceive a health threat to be more severe, (b) perceive themselves to be susceptible to this health threat, (c) perceive the preventive health behaviour

to be effective at reducing the likelihood of the poor health outcome, (d) perceive fewer barriers to adopting this behaviour, and (e) have greater confidence in their ability to apply that health behaviour (i.e. have a higher sense of self-efficacy). Cross-sectional studies have described individual associations between these five HBM factors with adherence to COVID-19 related preventive behaviours, including physical distancing (Badr et al., 2021; Gouin et al., 2021; Hsing et al., 2021; Tam et al., 2021). Longitudinally, perceptions of vulnerability to and severity of COVID-19 were associated with greater adherence to sanitary and physical distancing measures over one month (González-Castro et al., 2021). Self-efficacy and perceived barriers were also important mediators in the maintenance of physical distancing over three months (Tam et al., 2021). More longitudinal research is needed to assess which HBM factors are most strongly associated with adherence over time.

Although COVID-19 poses a health threat to individuals, non-adherence to physical distancing could put others at risk and may prolong the negative economic and social consequences of a pandemic. This communal threat may contribute to an enhanced sense of collectivity and shared identification with others facing the threat (Drury et al., 2020). Prior research indicates that individuals are more likely to adhere to health behaviours when they are perceived as legitimate and helpful to others also facing this threat (Drury et al., 2020). Therefore, in addition to evaluations of health risks and benefits to the individual as defined by the HBM, perceptions of severity of the virus to others as well as the efficacy of physical distancing in protecting others may be important motivation factors to consider when predicting adherence to physical distancing in the context of a pandemic. One study showed that individuals who were most adherent to physical distancing directives were more likely to perceive that these behaviours were beneficial to others close to them (Gouin et al., 2021). In contrast, another study showed that greater perceived severity of the virus to close others was associated with lower adherence intentions and behaviours (Scholz & Freund, 2021). These mixed cross-sectional findings highlight the need for longitudinal research to better understand how health beliefs related to the self and to others may influence adherence to physical distancing.

The theory of planned behaviour (TPB) (Ajzen, 1991) further posits that, in addition to perceived benefits, barriers, and self-efficacy, social norms also contribute to intentions and actual preventive behaviours. Social norms refer to the perceived social pressure to perform (or not) a behaviour (Ajzen, 1991). In times of uncertainty, individuals may rely on social norms to better understand what behaviours are approved of (i.e., social injunctive norms) and how others are generally behaving (i.e., descriptive norms) (Cialdini & Goldstein, 2004). Personal injunctive norms, or moral norms, the internalised rules of right and wrong with the responsibility to act accordingly (Manstead, 2000), may also influence adherence choices. Specifically, one personal injunctive norm, civic duty, or the sense of responsibility towards society to act a certain way, has been associated with greater restraint from social activities during the pandemic (French Bourgeois et al., 2020) and better overall adherence to physical distancing (Gouin et al., 2021). Descriptive and social injunctive norms have also both been positively associated with adherence to physical distancing, and other public health measures in cross-sectional research (Barile et al., 2021; Bicchieri et al., 2021; Gouin et al., 2021; Pollak et al., 2021). Longitudinally, two studies found a positive

association between descriptive norms and physical distancing behaviours (Hagger et al., 2021; Rudert & Janke, 2021). These results suggest that social norms may be important motivation-related factors associated with adherence during the first wave of the pandemic, but their longitudinal association with adherence over many months remains unknown.

In addition to theory-based predictors, emotional distress may hinder a person's motivation or ability to adhere to physical distancing guidelines. However, findings are mixed on this matter, with some suggesting that emotional distress is associated with lower adherence to physical distancing (Pollak et al., 2021), with stronger adherence to physical distancing (Lin et al., 2020), and others finding no association (Gouin et al., 2021). In cross-sectional research, the directionality of the association between emotional distress and adherence to physical distancing cannot be determined. As such, longitudinal research is necessary to better understand the associations between emotional distress and patterns of adherence to physical distancing over time.

Adherence to physical distancing cross-sectionally and over time has also been found to differ according to sociodemographic variables that may impact an individual's ability to stay home or avoid proximity with others. Specifically, employment status, having pre-existing health conditions, cohabitation status, being a caregiver or receiving caregiving, or being an essential worker outside the home (Gouin et al., 2021; Petherick et al., 2021) may limit a person's ability to adhere to distancing guidelines over time.

The first goal of the present study was to identify and describe groups of individuals with distinct adherence trajectories over an 8-month period as participants lived through the first and start of the second pandemic waves in Quebec, Canada. The second goal of the study was to determine how theory-based factors anchored within the HBM and TPB (perceived severity for self and others, susceptibility, benefits to self and others, barriers to adherence, self-efficacy, descriptive norms, personal and social injunctive norms) and emotional and socio-economic factors predicted membership in these trajectory groups. Multivariate models were used to identify independent predictors of physical distancing among these theory-driven factors.

Method

Participants and study design

In this longitudinal study, a cohort of 1003 participants representative of the adult (18 years and older) population of Quebec, Canada, in terms of age, sex, and urbanicity were recruited from a web panel managed by a market research firm. Participants completed the survey in French or in English. Details regarding the recruitment procedure and the characteristics of the baseline sample are described elsewhere (Gouin et al., 2021). Participants completed a first survey between 7 and 15 April 2020 (Time 1), corresponding to 23–32 days after the beginning of the local physical distancing directives. The second data collection period occurred between 19 May and 7 June 2020 (Time 2), nearing the end of the first wave of the pandemic. This period was marked by the reopening of schools, retail stores, and cultural and religious centers

in the province. Outdoor social gatherings were permitted with maintained physical distancing recommendations, but indoor gatherings in private residences were still prohibited. The third data collection period occurred from 28 September to 18 October 2020 (Time 3), corresponding to the start of the second wave of the pandemic as marked by the reintroduction of retail and restaurant closures, as well as reinstatement of part-time virtual schooling for high school students (Institut national de la santé publique du Québec, 2021). Although private gatherings were permitted again between Time 2 and Time 3, they were no longer permitted by the start of Time 3. Therefore, despite changes in population-level closures during the study period, individual-level physical distancing guidelines were mostly the same throughout.

All 1003 baseline participants were contacted and invited to participate again at both Time 2 and Time 3. Of the full sample, 658 participants (65.6%) completed Time 2 and 650 participants (64.8%) completed Time 3. A total of 789 (78.6%) participants provided responses for at least two time points and were included in the present study. Those who completed at least two time points were more likely to have a university degree ($\chi 2 = 4.33$, $df = 1$, $p = .04$) and were older ($t(1001) = 5.55$, $p < .01$, $M_{age} = 50.38$, $SD = 15.92$) compared to those who did not provide follow-up data ($M_{age} = 43.54$, $SD = 16.25$). No other differences in sociodemographic or adherence to physical distancing variables (described below) were observed between those who participated in one or two longitudinal follow-ups and those who were lost to follow-up. This study was approved by the Concordia University institutional ethics review board (#30012927).

Measures

Sociodemographic characteristics

A range of sociodemographic characteristics that may be associated with potential constraints to physical distancing were assessed. Participants provided information on their age, sex, highest attained level of education (primary school, secondary school, college or undergraduate degree, or post-graduate degree), household composition (living alone or with others), essential worker status (yes, no) and relationship status (single or in a relationship). Participants were classified as caregivers if they endorsed having caregiving responsibilities for young children, adults with disability, or older adults requiring daily physical assistance (vs. no caregiving responsibilities). Participants reported whether they have a physical health problem (respiratory, cardiac, or immunosuppression-related conditions) that increases their susceptibility to severe COVID-19; they were classified at low health risk if they had none of these conditions and at high health risk if they reported one or more of these physical health problems. The population density of participant's location was imputed using postal codes and categorised as rural, small/medium population centre, or large population centre based on Statistics Canada's (Statistics Canada, 2017) classification. These sociodemographic variables were collected at Time 1. Participant ethnicity was additionally collected at Time 2.

Health beliefs

Items were self-developed using published guidelines to assess cognitive and social constructs in the context of the COVID-19 pandemic (Ajzen, 1991, 2002). Participants completed ten items rated on a Likert-type rating scale ranging from 1 (Not at all) to 5 (Extremely) assessing their perceptions of the virus and the physical distancing guidelines according to the HBM (Rosenstock, 1974). Two items measured the extent to which respondents perceived that they were susceptible to being infected with the coronavirus (i.e., susceptibility for the self) and that the infection would be dangerous for them (i.e., severity for self). To capture the significant health threat of the pandemic to the in-group, participants also rated susceptibility and severity of COVID-19 for close others. Participants further evaluated their perceptions of how effective physical distancing measures were to protect them (i.e., benefits for self) and their close others (i.e., benefits for others) from contracting the virus. They responded to three items measuring the extent to which the physical distancing recommendations were financially costly for them, frustrating and unpleasant, and tiresome to apply. Responses to these three items were averaged to obtain an overall score for perceived barriers (Cronbach's $\alpha = .75$). Lastly, participants evaluated their confidence in their ability to adhere to the physical distancing recommendations (i.e., self-efficacy). The health beliefs questions were administered at Time 1.

Perceived social norms

Perceived social norms were measured using three self-developed items. Participants rated the extent to which they perceived that others were following the physical distancing recommendations (i.e., descriptive norms) on a scale ranging from 1 (Not at all) to 5 (Extremely). Collective and personal injunctive norms were also measured. To measure perceived collective injunctive norms, participants rated how their close others would react if they knew the respondent had not followed recommendations on a Likert-type rating scale ranging from 1 (they would very much approve) to 5 (they would very much disapprove). To measure personal injunctive norms, participants rated the extent to which they perceived it was their civic duty to follow these directives on a scale ranging from 1 (Not at all) to 5 (Extremely). Perceived social norms data were collected at Time 1.

Emotional distress

Depression/Anxiety. The 4-item Patient Health Questionnaire (Kroenke et al., 2009) was used to measure symptoms of depression and anxiety. Internal reliability for these items was good (Cronbach's $\alpha = .88$).

Loneliness. The Three-Item Loneliness Scale (Hughes et al., 2004) was used to measure perceived loneliness. Internal reliability for these items was good (Cronbach's $\alpha = .82$). Emotional distress variables were collected at Time 1.

Adherence to physical distancing

At all time points, participants rated their adherence in the last two weeks to five different individual physical distancing directives: minimised contact with others by

staying home, minimised non-essential errands outside the home, avoided receiving visitors at home, avoided social gatherings with more than two people, and maintained a two-meter distance from others when out in public. At Time 3, participants additionally rated their adherence to a sixth directive: self-isolated if you experienced symptoms of COVID-19. All items were rated on a 5-point Likert-type rating scale ranging from 1 (Never) to 5 (Almost Always) and averaged to provide an overall estimate of adherence to physical distancing recommendations. Internal reliability for these items was acceptable over time (Cronbach's α ranged from .77 to .84).

Statistical analyses

Group-based trajectory modeling (GBTM) was used to determine the overall change in adherence over time and to identify specific latent sub-groups of individuals following distinctive adherence trajectories (Nagin, 2014). In contrast to growth-curve modeling techniques that assume one population mean with individual participant trajectories evolving around this mean, GBTM is a form of finite mixture modeling that assumes that the population is composed of 'a mixture', or many groups of individuals who evolve together over time. GBTM aims to reduce within-group variability in trajectories and capture the population differences across groups (Nagin & Odgers, 2010). In this context, intra-group individual trajectories are considered identical or converging around the same adherence pathway whereas inter-group individual trajectories are considered heterogeneous.

The number of latent trajectory groups identified in the model was statistically specified using the Bayesian Information Criterion (BIC), with a minimum size constraint of 50 participants per group, following recommended guidelines (Jenkins & Quintana-Ascencio, 2020). The BIC was used in conjunction with the cross-validation error (CVE) to test the predictive power of the model. The CVE compares the data to the model parameters and provides an index of the absolute difference between the true values and the predicted values. Smaller BIC and CVE values indicate better model fit (Nielsen et al., 2014). The model was also fitted using polynomial degree of fit (p). Models were fitted at $p=1$ and $p=2$ to compare the fit of linear and quadratic trajectories, respectively. The BIC and CVE values tend to decrease as the number of trajectories (n) and the polynomial degree of fit (p) increase. The best fitting model was selected based on having minimised BIC and CVE values and meeting the minimum participant size constraint. The maximum likelihood estimator (MLE) was used to obtain an estimation of the probability that each participant belongs to each group and provide a classification of each participant by most probable group (Nielsen et al., 2014). All GBTM analyses were conducted using the crimCV package in R (Nielsen, 2018).

Following the validation of model parameters and the identification of trajectories, descriptive analyses of sociodemographic characteristics of each trajectory group were conducted. Statistical differences across groups were tested using omnibus univariate analyses of variance (ANOVA) for continuous variables and chi-square analyses for categorical variables. When statistically significant differences were noted, post-hoc pairwise comparisons were conducted to determine where group differences lied using independent samples t-tests for continuous variables and 2×2

chi square analyses for categorical variables. These analyses were conducted in SPSS version 27.

Next, a multinomial logistic regression model was estimated to identify the sociodemographic, cognitive, and emotional factors that independently predicted group membership in the adherence sub-groups determined by the GBTM process. This technique estimates the odds ratio (OR) of group membership for each trajectory compared to the reference group based on each individual predictor, while accounting for the variance of all other predictors. Significance testing with alpha set at .05 was used to determine whether predictors significantly differentiated between trajectory groups. Sociodemographic, cognitive, and emotional predictors measured at Time 1 were included in the regression model. This analysis was conducted using the nnet package in R (Ripley & Venables, 2021).

Results

Participants in the study had a mean age of 50.38 ($SD = 15.92$, range of 18–89) years and 53.1% were female. In addition, 93% of respondents reported being White. Across the entire sample, a hierarchical linear model described a significant negative linear effect of time on adherence to physical distancing recommendations (b(SE) = −0.24 (0.01), $p > .001$).

The GBTM procedure demonstrated that a model with four distinct quadratic trajectories was best fitting (Supplementary Materials 1). Participants in Group 1, representing 50% of the sample, demonstrated high and sustained levels of adherence during the studied pandemic period, and were thus considered 'high adherers'. This group was considered the reference group for further analyses. Participants in Group 2, representing approximately 32% of the sample, were among the most adherent but were less cautious to those in Group 1 over time, and were considered the 'slow decliners'. Participants in Group 3, representing 10% of the population, demonstrated a pattern of fluctuating adherence with decreases from Time 1 to Time 2, but with an adherence trajectory that was revised upwards at Time 3, in line with changes in population-level governmental restrictions over the course of the study period. This group was named the 'fluctuating adherers' to reflect their changing behaviours as the pandemic evolved. Group 4 participants, representing almost 8% of the sample, saw their levels of adherence decrease more rapidly over the entire study period. They were thus considered the 'fast decliners'. Figure 1 depicts the adherence trajectories for the full sample and the four groups derived from the GBTM estimation. Sensitivity analyses demonstrated that these trajectories were replicated among the subsample of 519 (51.7%) participants who provided data for all three time points.

Table 1 presents the sociodemographic characteristics of the groups defined by the GBTM model. Significant differences in age were noted across groups. The fast-declining group was younger and the high adherence group was older than all other groups. The high adherence group also had a larger percentage of females than the slow declining group. More high-adhering participants completed college/undergraduate and post-graduate studies compared to fluctuating and slow declining participants. The fluctuating group had a higher proportion of essential workers than

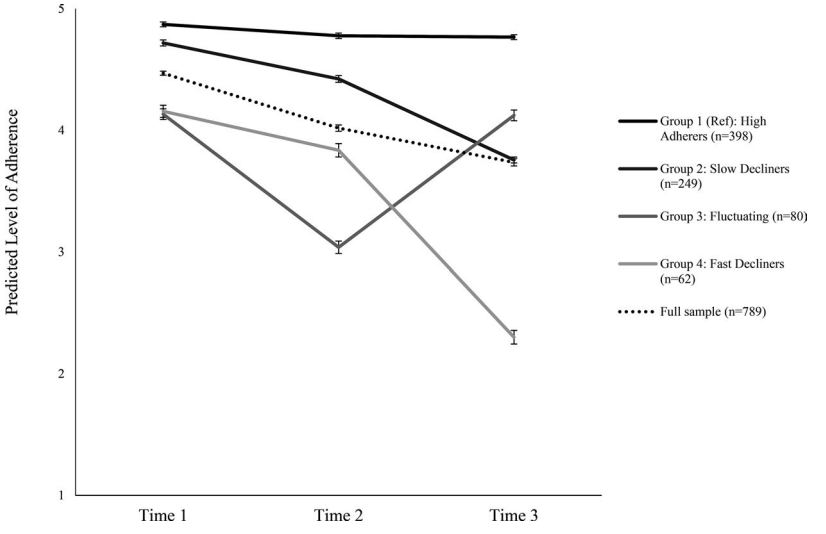

Figure 1. Trajectories of adherence to physical distancing guidelines. Time 1 corresponds to March-April 2020, the start of the first wave of the pandemic. Time 2 corresponds to May-June 2020, at the end of the first wave of the pandemic. Time 3 corresponds to September-October 2020, at the start of the second wave of the pandemic. The predicted levels of adherence at the different times resulted from the initial observations adjusted to the evolution of the groups' behaviour. Error bars represent the standard error of the mean. Ref = reference group.

the high adhering group. The four groups of participants had relatively similar proportions on all other sociodemographic characteristics.

Table 2 presents the estimation results of the multinomial logistic regression models predicting the odds of belonging to each trajectory group compared to the high adherence reference group. Factors that significantly distinguished between adherence trajectory groups included perceived benefits to the self and to others, perceived barriers, self-efficacy, perceived susceptibility of others, descriptive norms, sense of civic duty, depression/anxiety, age, sex, and education. The fast-declining trajectory group tended to be younger, had lower levels of education, perceived fewer benefits to others, had lower self-efficacy, had a lesser sense of civic duty, and were less depressed/anxious at Time 1 compared to the high adherence group. Participants in the fluctuating adherence group tended to have lower levels of education, perceived fewer benefits to themselves, perceived greater barriers and a lesser sense of self-efficacy, and had a lesser sense of civic duty at Time 1 compared to the high adherence group. Finally, those in the slow-declining group were more likely to be male, perceived higher barriers to adherence and less self-efficacy, perceived fewer benefits to others, and also were more likely to perceive that others were adhering to recommendations (i.e., higher descriptive norms) at Time 1 compared to the high-adherence group.

Discussion

The goal of this study was to examine psychosocial predictors of group-based trajectories of adherence to physical distancing recommendations during the first two

Table 1. Group sociodemographic characteristics.

Factors	Group 1: High adherers ($n = 398$)	Group 2: Slow decliners ($n = 249$)	Group 3: Fluctuating ($n = 80$)	Group 4: Fast decliners ($n = 62$)	**Omnibus F/ χ^2statistic**	p-value
	M (SD)	M (SD)	M (SD)	M (SD)		
Adherence at T1	4.9(±0.2)[abc]	4.7(±0.3)[bc]	4.1(±0.7)	4.2(±0.7)	F = 120.4	< 0.001
Adherence at T2	4.8(±0.3)[abc]	4.4(±0.4)[bc]	3(±0.6)[c]	3.8(±0.8)	F = 367.0	< 0.001
Adherence at T3	4.8(±0.3)[abc]	3.8(±0.4)[bc]	4.1(±0.5)[c]	2.3(±0.6)	F = 772.1	< 0.001
Age	53.1(±15.8)[abc]	49.7(±15.3)[c]	46.3(±15.2)[c]	40.9(±15)	F = 13.8	< 0.001
	n (%)	n (%)	n (%)	n (%)		
Sex (Female)	231(58%)[a]	117(47%)	40(50%)	31(50%)	χ^2 = 8.9	.04
Ethnicity (White)	305 (76.6%)	200 (80.3%)	58 (72.5%)	51 (82.3%)	χ^2 = 4.3	.23
Highest Education					χ^2 = 24.1	.02
Primary School	2(0.5%)	1(0.4%)	1(1.3%)	1(1.6%)		
Secondary School	100(25.1%)[b]	71(28.5%)[b]	33(41.3%)	22(35.5%)		
College/Undergraduate	243(61.1%)	160(64.3%)	43(53.8%)	36(58.1%)		
Post-Graduate	53(13.3%)[ab]	17(6.8%)	3 (3.8%)	3(4.8%)		
Essential Worker	50(12.6%)[b]	39(15.7%)	19(23.8%)	13(21%)	χ^2 = 9.8	.03
Lives Alone	80(20.1%)	51(20.5%)	8(10%)	10(16.1%)	χ^2 = 5.2	.16
Single	141(35.4%)	89(35.7%)	24(30%)	27(43.5%)	χ^2 = 2.8	.42
No Caregiving	336(84.4%)	216(86.7%)	63(78.8%)	47(75.8%)	χ^2 = 6.6	.10
Population Centre					χ^2 = 9.6	.15
Rural	74(18.6%)	61(24.5%)	22(27.5%)	13(21%)		
Small/Medium	26(6.5%)	8(3.2%)	4(5%)	1(1.6%)		
Large	298(74.9%)	180(72.3%)	54(67.5%)	48(77.4%)		
Low Health Risk	236(59.3%)	163(65.5%)	54(67.5%)	41(66.1%)	χ^2 = 3.9	.28

a statistically significant difference from Group 2 at p <.05, b statistically significant difference from Group 3 at p <.05, c statistically significant difference from Group 4 at p <.05. Note. All sociodemographic characteristics were measured at Time 1 except for Ethnicity (White), which was measured at Time 2.

waves of the COVID-19-pandemic. Results showed that despite overall declining adherence to physical distancing during the study period, four distinct adherence trajectories emerged. About half of the participants maintained stable adherence over time and were deemed high adherers. Three additional distinct trajectories of changing adherence over time were observed: a fluctuating group with wavering levels of adherence across pandemic waves as population-level distancing measures changed; a slow-declining group; and a fast-declining group. Self-efficacy, perceived barriers, and sense of civic duty were the strongest psychosocial predictors of adherence to physical distancing across groups. These results highlight both shared and distinct health beliefs and social norms across different trajectories of self-reported adherence to physical distancing over time.

Both shared and specific psychosocial predictors emerged as most relevant in predicting non-adherence to physical distancing over time. Self-efficacy emerged as the strongest predictor across all three trajectories with poorer adherence. Similarly, perceived barriers, a key construct in the HBM, was an independent predictor of adherence to physical distancing for both the slow-decliner and fluctuating groups. Thus, hindrances to physical distancing, whether due to one's perceived inability to adhere or the high emotional and material costs of adherence, primarily affected motivation to maintain physical distancing behaviours over time. These findings are in line with self-efficacy theory, which postulates that perceptions of self-efficacy will determine how much effort individuals will expend and how long they will persist in the face of potential obstacles to behaviour change (Bandura, 1977). These results are also concordant with prior meta-analyses reporting

Table 2. Predictors of trajectories of physical distancing.

	OR: Fast decliners	OR: Fluctuating	OR: Slow decliners
Severity for Self	0.814	0.87	0.834
Susceptibility of Self	0.971	1.09	0.997
Benefits for Self	1.171	0.613*	0.926
Perceived Barriers	1.024	1.448*	1.207*
Self-Efficacy	0.367***	0.414***	0.685**
Severity for Others	1.151	1.087	0.86
Susceptibility of Others	0.977	0.605*	0.98
Benefits for Others	0.523**	0.967	0.778
Descriptive Norms	1.019	1.21	1.291*
Injunctive Norms	0.924	1.074	0.863
Sense of Civic Duty	0.613*	0.598*	1.13
Loneliness	1.135	0.947	0.981
Depression/Anxiety	0.859*	1.038	0.958
Age	0.953***	0.985	0.99
Sex (Female)	1.025	1.224	1.472*
Education	0.703*	0.715*	0.846
Essential Worker (No)	1.404	1.491	1.143
Household Composition (Lives Alone)	1.447	2.099	0.913
Relationship status (Single)	0.671	1.189	1.015
Caregiver status (No)	1.257	0.887	0.784
Population Centre (Rural)	1.168	0.926	0.951
Health Risk Status (Low)	1.524	0.993	0.928

* $p<.05$, ** $p<.01$, *** $p<.001$. OR = Odds Ratio.

Note. Odds ratios are calculated with the High Adherers as the reference group. Information in parentheses refers to the categorical level coded as 0.

independent associations of self-efficacy and perceived barriers with a range of health-related behaviours (Carpenter, 2010).

In addition, perceptions of civic duty and benefits to others emerged as important predictors of adherence trajectories. Perceptions of civic duty and benefits to others represent prosocial motivations for physical distancing. Although a prior review highlighted the role of perceived personal severity and susceptibility on adherence (Bish & Michie, 2010), prosocial motives were more strongly associated with adherence than self-oriented motivations in the context of the COVID-19 pandemic. Cross-sectional research has shown that greater prosocial attitudes in general was associated with better adherence to physical distancing (Coroiu et al., 2020). Experimental studies also found that framing physical distancing as a prosocial behaviour was associated with greater subsequent adherence compared to messaging using self-interested or threatening language (Heffner et al., 2021; Jordan et al., 2021). The pandemic context may therefore lead to an emergent shared social identity that promotes actions toward collective well-being (Drury et al., 2020)

Unique psychosocial correlates of adherence were found for each trajectory group. Individuals in the fast declining group, representing nearly 8% of the sample, were among the least adherent during the entire study period. Participants in this group perceived that physical distancing was less beneficial to others and felt a lower sense of civic duty to adhere. Individuals in this group therefore may not perceive physical distancing as a prosocial act benefitting others and society, and may instead weigh the personal benefits of in-person socialisation above the benefits that physical distancing may have to their close others and to society (Bigot et al., 2021). This group also reported decreased anxiety and depression compared to the high adherers,

tended to be younger, and had lower education levels. Although the onset of the COVID-19 pandemic was associated with greater emotional distress in the population (Heanoy et al., 2020), this group of individuals may conversely feel less distressed as their social life is less disrupted compared to others who are more stringently adhering to physical distancing. However, younger and less educated individuals may suffer most from the lost opportunities associated with the mass closures of sport, leisure, non-essential employment, and in-person education during the pandemic (Lemieux et al., 2020; Martin et al., 2021; Sahu, 2020). Taken together, this group of individuals may have suffered many lost opportunities and changes due to the pandemic, potentially decreasing their motivation to adhere to physical distancing recommendations in favour of in-person social contacts, possibly to cope emotionally with the situational consequences.

Individuals in the fluctuating adherence group, accounting for 10% of the sample, reported greater perceived barriers to physical distancing, lower self-efficacy, fewer benefits of physical distancing behaviours to themselves, decreased susceptibility of their close others to the virus, and a decreased sense that it is their civic duty to follow distancing recommendations, compared to high adherers. This group also had lower education levels. The fluctuating group demonstrates a pattern of non-adherence that may be both risk-adapted and necessity-driven (Denford et al., 2021). Specifically, this group displayed fluctuating behaviours paralleling changes in public markers of risk - the changes in population-level governmental restrictions - as the pandemic evolved. Their lower perceptions of their ability to execute these behaviours and their decreased prosocial evaluations of physical distancing suggest that this group may not see much value to physical distancing and will therefore abandon it when they have the opportunity to do so. In addition, individuals with lower levels of education may have less opportunity for physical distancing and staying home due to potentially precarious employment during the pandemic. Evidence from GPS data suggests that individuals from low socioeconomic (SES) backgrounds were more mobile than those in high SES neighborhoods (Weill et al., 2020). Thus, the fluctuating behaviours in this group may also reflect some necessity-driven reasons of non-adherence to maintain employment as essential workers or search for new work as non-essential businesses closed.

Compared to high adherers, slow decliners (representing almost 32% of the sample) had higher perceptions that close others were adhering to physical distancing, perceived greater barriers to adherence, reported lower self-efficacy and were more likely to be male. Descriptive norms have been associated with greater subsequent physical distancing (Hagger et al., 2021; Rudert & Janke, 2021). However, perceiving others are adhering in combination with greater personal difficulties in applying these behaviours themselves may promote the use of free-riding strategies over time, i.e. benefiting from the protection incurred by the high adherence of others while decreasing personal adherence and associated costs (Yong & Choy, 2021). Experimental research shows that perceptions of high population vaccination rates in a fictitious pandemic scenario were associated with enhanced perceptions of individual protection and decreased personal vaccination intentions (Betsch et al., 2013), supporting the idea of free-riding during health crises. However, it is notable that despite an overall

declining trajectory, the slow declining group remained among the most adherent during the study period. Thus, although free-riding strategies might emerge among those perceiving high population adherence to physical distancing, high descriptive norms could protect against quicker deterioration of adherence behaviours.

To investigate the public health relevance of these observational findings, randomised controlled trials should be conducted to examine whether manipulating these social and cognitive constructs increases physical distancing adherence behaviours, particularly among high risk groups. Nonetheless, these results have important implications for public health interventions to increase adherence to physical distancing recommendations, as they provide nuance about the role of perceived descriptive norms and prosocial attitudes on adherence to physical distancing over time. In the short term, experimental studies manipulating descriptive norms and prosocial messaging were found to increase intended and actual adherence to physical distancing behaviours (Jordan et al., 2021; Kitamura & Yamada, 2020). However, the results of the current study suggest that higher descriptive norms may also lead to a longitudinal decrease in adherence for a subgroup of individuals. Public health messaging may therefore seek to promulgate prosocial messaging highlighting the importance of sustained collective and individual efforts, the benefits to others of adherence, and promoting a sense of civic duty to mitigate against free-riding tendencies. These findings also highlight the importance of self-efficacy and perceived barriers in long-term adherence to physical distancing. Public health campaigns could aim to enhance self-efficacy by capitalising on modeling techniques, providing suggestions or instructions on how to distance effectively, or minimising emotional arousal associated with these behaviours (Bandura, 1977). This could include depicting scenarios in which physical distancing is effectively implemented and including portrayals of how to overcome potential barriers to distancing in various settings. Messaging targeting both self-efficacy and prosocial attitudes may be particularly helpful in promoting adherence, although research is needed to evaluate this question. Finally, younger and less educated individuals are also at higher risk of non-adherence to physical distancing. Public health campaigns should seek to tailor messaging to the specific challenges to adherence in these SES and age groups. This study was conducted during the first year of the pandemic when physical distancing was considered a key strategy to mitigate the spread of the virus. As the pandemic evolves and the associated public health measures change, these findings may inform how to promote habitual protective behaviours, such as indoor face mask use, as well as one-time and repeated protective behaviours such as yearly vaccinations.

The longitudinal design along with the use of theory-informed psychosocial predictors are key strengths of the present study. However, the results of this study are important to consider within certain limitations. Predictors of adherence patterns were measured at the start of the pandemic in March 2020. Research has suggested that the association between sociodemographic variables and personality traits with adherence to public health measures changed over time (Wright & Fancourt, 2021). Further, perceptions of health beliefs, social norms, and emotional distress are mutable and may have changed over time as the pandemic progressed. Moreover, behaviour change theories highlight that habitual, impulsive, or automatic tendencies also affect

behaviour change (Hagger et al., 2021). These factors were not measured in this study but they may have important implications for one's perceptions of self-efficacy and the maintenance of physical distancing. Although they can be challenging to measure, prior research has found they are also key determinants of future protective health behaviours (Brown et al., 2020). Thus, they should be part of comprehensive model of behaviour change investigated in future research. It is also important to note that the results of this study may not be generalisable across different socio-political contexts. Specifically, trust in the government and interpersonal trust have emerged as important predictors of adherence to physical distancing and compliance with other public health measures during the pandemic (Petherick et al., 2021; Wright et al., 2021). Generally high rates of trust in the government and in other citizens were reported in Quebec during the first eight months of the pandemic, despite some decreases over time (Institut de la confiance des organisations, 2020). In addition, later in the pandemic, the public health recommendations for managing the health crisis changed in favour of other personal protective behaviours in addition to physical distancing. Research has shown that adherence to mask wearing and vaccination intentions and administration are increasing with concomitant decreases in adherence to physical distancing (Petherick et al., 2021). Future research is needed to observe patterns and predictors of adherence to mask wearing, other personal protective sanitary measures, and vaccination intentions and behaviours. Furthermore, although the sample was recruited to be representative of the population in terms of age, sex, and urbanicity, participants were mostly White and part of a web panel, leading to some sampling bias. Similarly, participants who provided follow-up data were older and more educated, leading potentially to an under-estimation of poor adherence in the longitudinal analyses.

In conclusion, this study identified four patterns of adherence to physical distancing over the first two waves of the pandemic, including one pattern of high adherence and three patterns of varying levels of adherence over time. The most important predictors of non-adherence included perceptions of low self-efficacy and high barriers to adherence, as well as lower prosocial attitudes towards physical distancing. Public health messages targeting these factors may be most relevant to promote sustained adherence to physical distancing over time in the context of a pandemic.

Author contributions

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Data availability statement

The data that support the findings of this study are available from the corresponding author, [JPG], upon reasonable request.

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