Psychology & Health

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/gpsh20

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To cite this article: Robin Wollast, Mathias Schmitz, Alix Bigot, Niko Speybroeck, Éric Lacourse, Roxane de la Sablonnière & Olivier Luminet (20 Nov 2023): Trajectories of health behaviors during the COVID-19 pandemic: a longitudinal analysis of handwashing, mask wearing, social contact limitations, and physical distancing, Psychology & Health, DOI: 10.1080/08870446.2023.2278706

To link to this article: https://doi.org/10.1080/08870446.2023.2278706

Published online: 20 Nov 2023.

PSYCHOLOGY & HEALTH
https://doi.org/10.1080/08870446.2023.2278706

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Trajectories of health behaviors during the COVID-19 pandemic: a longitudinal analysis of handwashing, mask wearing, social contact limitations, and physical distancing

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ABSTRACT

Aim: This study aimed to investigate the associations between health behavior adherence and psychological factors during the COVID-19 pandemic, with a particular focus on identifying trajectories of handwashing, mask wearing, social contact limitations, and physical distancing.

Methods: We employed a multi-trajectory group-based approach to analyze data from 6026 Belgian residents, including 60% women, with an average age of 52.65. Data were collected over six waves spanning from April 2021 to December 2021.

Results: Participants were categorized into trajectory groups based on persistently low (11.9%), moderate-low (20.9%), moderate-high (39.1%), and high (28.1%) levels of adherence to the specified health behaviors. Our findings indicate a declining trend in health behavior adherence over the study period. Additionally, we observed that females, older individuals, and those with prior COVID-19 infection had a higher likelihood of belonging to trajectory groups characterized by the highest levels of health behavior adherence. Similarly, individuals with positive vaccination intentions, a heightened perception of consequences, and increased health anxiety demonstrated greater adherence to health behaviors over time. Furthermore, our investigation into the relationship between health behaviors and mental health revealed that participants in trajectory groups with higher levels of adherence to social contact limitations and physical distancing reported increased feelings of loneliness and decreased life satisfaction.

Conclusions: The COVID-19 pandemic has reshaped our lives, and while vaccines have marked progress, maintaining health behaviors is crucial for virus prevention. To address potential mental health challenges from sanitary measures, policies and communication should promote health behaviors while acknowledging their psychological impact.

ARTICLE HISTORY

Received 13 February 2023
Accepted 28 October 2023

KEYWORDS

Covid-19; health behavior; mental health; longitudinal; sanitary behavior; Belgium

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Supplemental data for this article is available online at https://osf.io/cq2m6/

On 11 March 2020, the World Health Organization declared the COVID-19 outbreak a global pandemic (Cucinotta & Vanelli, 2020). In order to minimize the virus circulation, many governments introduced measures aiming to reduce the number of physical interactions and encouraged the adoption of protective and social measures to attenuate the rapid worldwide spread (WHO, 2020a). In this context, the vast majority of countries followed public health recommendations and reinforced health behaviors such as handwashing, mask wearing, physical distancing, and limitations of social contact. While the adoption of health behaviors is crucial for slowing the spread of infectious diseases (for a meta-analysis, see Talic et al., 2021), behavioral changes such as face coverings and self-isolation, as a response to these national health recommendations were difficult to apply for some individuals, as it may have deteriorated their quality of life. Consequently, some people were reluctant to comply with the rules during COVID-19 lockdowns, from rejecting mask wearing to not following social contact limitations. In this context, the COVID-19 pandemic is an ideal testing ground to better understand which factors can facilitate or hinder the adoption of these health behaviors. Therefore, the purpose of the present study aims to investigate the stability and changes connected to handwashing, mask wearing, limitations of social contact, and physical distancing within a period of eight months during the COVID-19 pandemic among a large sample of French speaking Belgian participants ($N=6026$). Additionally, the present research aims at analyzing these health behavior trajectories through the lens of key psychological and mental health factors during the COVID-19 crisis. Understanding the associations between health behavior and mental health during the COVID-19 pandemic is critical to devising preventive interventions and new policies, as well as to developing sustainable health emergency preparedness to deal with future pandemics.

Health behaviors during the COVID-19 pandemic

The present research focuses on four major health behaviors: handwashing, mask wearing, physical distancing, and limitations of social contact. Handwashing is a classical protective health behavior (WHO, 2020b). In a systematic review of physical interventions employed to reduce the transmission of respiratory viruses, handwashing was indicated to be effective with a meta-analytic summary estimate of a 45–55% reduction in transmission (Jefferson et al., 2009). Similarly, a systematic review of the effectiveness of personal protective measures in preventing H1N1 pandemic influenza transmission in human populations indicated a 38% reduction in transmission with handwashing (Saunders-Hastings et al., 2017). In sum, most people understand the importance of handwashing to reduce disease transmission and washing hands frequently is often noted as a reaction (Pogrebna & Kharlamov, 2020).

Three other health behaviors—limiting social contacts by staying home, respecting physical distancing in public places, and face coverings—are considered avoidant behaviors (Bish & Michie, 2010). Avoidant behaviors are more challenging to adopt and maintain because they may alter fundamental social needs among many individuals. While limitations of social contact and physical distancing were found to be effective strategies to flatten the pandemic curve, it was difficult for people to inhibit their natural tendency to interact with others (Rigotti et al., 2020). The same logic applies for face coverings: While wearing face masks reduces the risk of transmission of viral respiratory disease (for a review, see Howard et al., 2021), there are numerous psychological complications associated with wearing masks such as hindering emotion recognition and deteriorating effective communication. This increases social distancing between individuals (Carbon, 2020; Marler & Ditton, 2021).

Sociodemographic and psychological differences in health behaviors

Scholars have shown that men and women have differing perceptions and adoptions of health behaviors (e.g. Dekeyser et al., 2023). For instance, Haischer et al. (2020) evidenced that women reported wearing a mask more often than men, because masks may have been viewed as a sign of fragility or weakness among some men (Capraro & Barcelo, 2020). In the same vein, Howard (2021) found that men were more likely to have perceived face masks as infringing on their independence, whereas women were more likely to have perceived face masks as uncomfortable. Similarly, women washed their hands more frequently than men (Bigot et al., 2021), and they were also more likely to follow recommendations regarding social and physical distancing rules as compared to men, driven by women's greater concerns about health problems and their transmission to family members (Guo et al., 2021).

Similar differences are observed among age groups. For instance, young individuals wore masks less often (Hart & Opielinski, 2020) and washed their hands less frequently (Bigot et al., 2021) than their middle age and older counterparts. Additionally, older people were having significantly fewer close contacts than younger people, which was in line with the public health authorities' recommendations (Canning et al., 2020). Taken together, these studies suggested that younger men were less likely to adopt health behaviors than the other gender and age groups.

Similarly, research has demonstrated associations between health behavior adherence and psychological factors (e.g. Schumpe et al., 2022; Stroebe et al., 2022; Van Lissa et al., 2022). Specifically, health anxiety, risk perception, infection status (e.g. have been previously infected by the virus), and vaccine intention were positively associated with adherence to health behaviors (e.g. Bigot et al., 2021; Schmitz et al., 2022a, 2022b). However, much of this work has been cross-sectional, making causal inferences difficult. Consequently, we would expect to replicate these effects using longitudinal methods, especially group-based trajectory modeling (van der Nest et al., 2020). To go further, one of the goals of the present research is to explore associations between health behaviors and mental health, over time.

COVID-19 and mental health

Adopting such radical behavior changes within a few days and for a long period of time was hard and may have deteriorated individuals' mental health. Specifically, although these self-isolating rules were vital, they also undermined deep-rooted needs for social bonding and could have thus worsened people's emotional well-being during difficult times. When people isolated themselves, they withdrew from the nourishment and support of others. Indeed, using cross-sectional data, Stickley et al. (2020) found that loneliness was associated with an increased risk for not engaging in COVID-19 preventive behaviors (see also Wollast, Preece, Schmitz, et al., 2023). Specifically, they found that lonely people were less likely to adopt protective behaviors such as not wearing a mask or not respecting social distancing from people when outside. We therefore investigated whether the high adoption of health behaviors can create a burden for mental health, and whether individuals who demonstrated high adherence to public health recommendations were more at risk to isolate themselves and experience psychological distress.

The COVID-19 pandemic affected everyone, triggering a worldwide mental-health crisis. In that challenging time, the increasing number of COVID-19 cases, risk of infection, social isolation, economic impact, and other concerns about the pandemic contributed to feelings of psychological distress for many people globally (e.g. Mann et al., 2020; Mertens et al., 2020). As lockdowns took effect in cities around the world, individuals reported high levels of loneliness and psychological distress (e.g. Aknin et al., 2021; Gamonal-Limcaoco et al., 2022; Van Breen et al., 2022; Wollast, Preece, Schmitz, et al., 2023).

Taken together, these studies suggested that limiting social contacts and respecting physical distancing created a physical and social distance from others, which may have been challenging as they pushed individuals against their deep instinct for togetherness. Similarly, wearing a face mask also created such distance, as it deteriorated communication between individuals (e.g. Marler & Ditton, 2021). Thus, we expected that high (vs. low) levels of adherence to limitations of social contact, physical distancing, and wearing masks would have been associated with high levels of loneliness and life satisfaction, two main mental health indicators experienced during the COVID-19 pandemic. However, we hypothesized that handwashing would not be associated with mental health concerns, as it is considered as a classic health behavior that does not create any distance between people.

National context

At the initial time of data collection (from 1 April to 2 December 2021), lockdown-mandates were still in place in Belgium to fight the third COVID-19 wave. Figure 1 reports the vaccine doses, COVID-19 cases per million people, ICU patients, and death cases, and Figure 2 shows the severity of the measures in Belgium (Mathieu

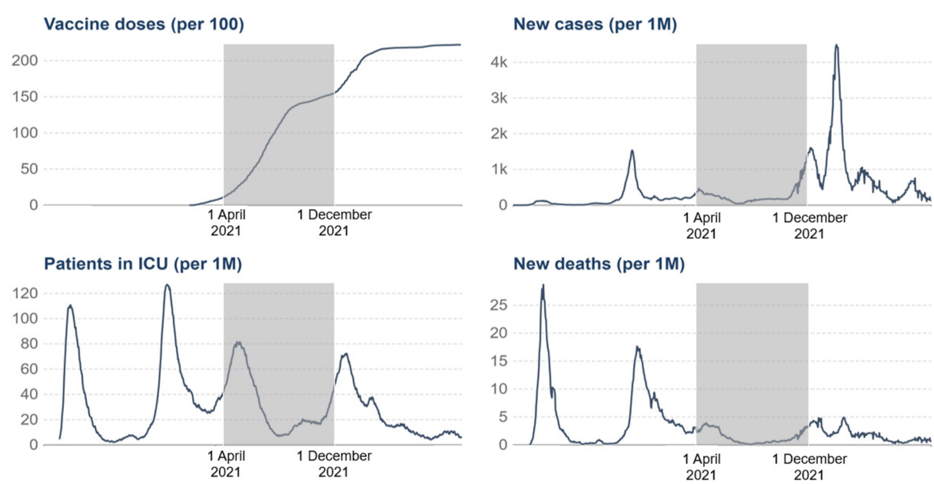

Figure 1. Vaccine doses, daily new confirmed cases, ICU patients, and death cases in Belgium (adapted from Mathieu et al., 2023). the grey area indicates the period of our data collection.

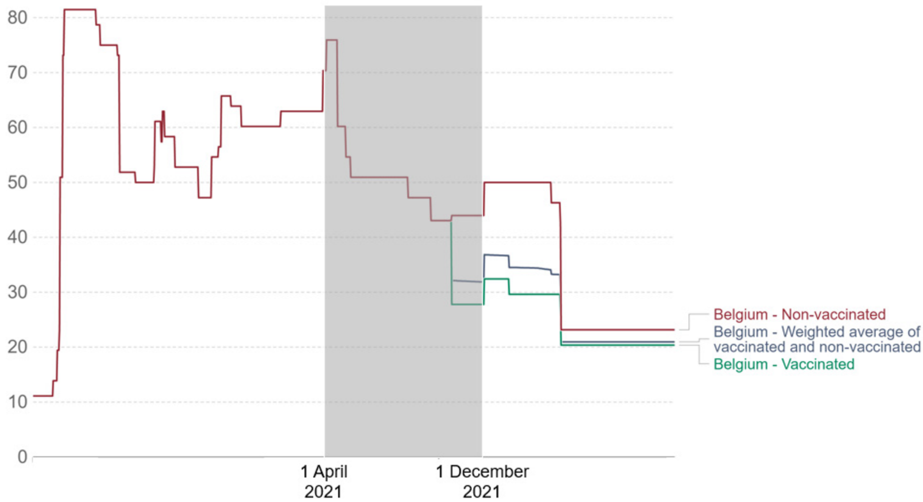

Figure 2. The stringency index is a composite measure based on nine response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100 (100 = strictest). If policies vary at the subnational level, the index shows the response level of the strictest subregion (adapted from Mathieu et al., 2023). the grey area indicates the period of our data collection.

et al., 2023). As can be seen, Belgium experienced a third peak in confirmed cases during data gathering. The Belgian government tended to impose tighter but similar restrictions compared with the other European countries (Hale et al., 2021). In this context, Belgium implemented several rules (e.g. closing schools and universities, non-food stores and close contact jobs, imposing travel restrictions, applying expensive fines for not complying with the regulations) and adjusted them based on the national health situation. Ultimately, while complying with health behaviors was crucial to handle new COVID-19 cases, a non-negligible proportion of Belgian's population still refused to follow the rules during COVID-19 lockdowns (e.g. 'lockdown parties'; Reuters, 2021), from rejecting mask wearing to not following physical and social distancing recommendations. Understanding the temporal dynamics of these health behaviors and identifying individuals who demonstrated difficulties adopting to these sanitary behaviors were essential to better confront global health threats such as the COVID-19 pandemic. It also helped to adapt specific interventions to particular communities.

Overview of the present work and hypotheses

The present study analyzes the trajectories of handwashing, mask wearing, limitations of social contact, and physical distancing within a period of eight months during the COVID-19 pandemic (from April 2021 to December 2021) among French speaking Belgian residents ($N = 6026$). We aimed at identifying groups of individuals who followed specific dynamics in terms of magnitude (i.e. low, moderate, high), direction (i.e., increasing, stable, decreasing), and shape (i.e. constant, linear, quadratic, or cubic) of the four health behaviors over time. To characterize patterns of variation in health behaviors, we conducted a multi-trajectory latent class growth analysis (Nagin et al., 2018) to identify homogeneous subgroups of health behavior adherence trajectories within the larger heterogeneous population. Next, we aimed at identifying trajectory groups associated with sociodemographic and psychological variables. Finally, we aimed at analyzing whether health behavior trajectories are associated with two outcomes related to mental health.

Hypothesis 1. Were health behavior responses heterogeneous or homogeneous in a large sample of Belgian residents? We expected to identify distinct subgroups of trajectories characterized by different levels of adherence (i.e. low, moderate, high) to handwashing, mask wearing, limitation of social contacts, and physical distancing over time. Furthermore, we postulated declining trajectory shapes for all health behaviors, in line with the improved national epidemiological conditions regarding new COVID-19 cases and the relaxation of COVID-19 restrictions during that period in Belgium.

Hypothesis 2. Were trajectories of health behaviors interconnected? We hypothesized a strong overlap between trajectory group membership reflecting avoidant behaviors (social contact limitations, physical distancing, and mask wearing). For instance, individuals who showed high (or low) levels on physical distancing would be more likely to show higher (or lower) levels on social contact limitations and mask wearing. Furthermore, we postulated weaker associations with handwashing because it is considered as a more classic and non-avoidant behavior, whereas the three others are avoidant behaviors.

Hypothesis 3. Were trajectories of health behaviors manifested similarly when they were considered simultaneously? We postulated that when handwashing, mask wearing, limitations of social contact, and physical distancing were considered simultaneously in the same model, multi-trajectory groups would follow the same pattern as observed in Hypothesis 1, when each health behavior was considered separately.

Hypothesis 4. Were sociodemographic characteristics and COVID-19 related variables associated with different health behavior trajectories? We expected trajectories of health behaviors would be associated with age and gender. Specifically, we hypothesized that younger men would be more likely to follow trajectories characterized by low levels of health behavior adherence. Similarly, we expected that trajectory groups would be positively associated with COVID-19 related questions including: infected by the COVID-19, vaccination intention, perceived consequences of being infected, and health anxiety.

Hypothesis 5. Did people who presented different health behavior trajectories differ in several indicators of mental health? We hypothesized that individuals reporting higher levels of adherence to limitations of social contact, physical distancing, and mask wearing (i.e. avoidant behaviors) over time would also experience higher loneliness and lower life satisfaction. Additionally, we expected that these associations would not hold for handwashing.

Method

This study complies with the APA ethical regulations for research on human subjects and all participants gave online written informed consent, as approved by the institutional review boards of the principal investigator. Raw data, syntax, questionnaires, and additional elements can be found in the online supplementary material (https://osf.io/cq2m6/).

Participants and procedure

The total initial sample comprised 6026 French-speaking Belgian residents. Participants were recruited *via* Belgian online newspapers, mailing list from universities, and social media platforms. Additionally, we also relied on Facebook advertising to collect additional young participants. To be consistent with the type of analysis used, participants who completed less than three waves of data collection were removed from the present study (Nagin, 2005). Based on these exclusion criteria, the final sample was composed of 1762 participants. The sample comprised 662 men and 1100 women. Age was measured as a continuous variable ($M = 52.65$; $SD = 15.29$; from 18 to 91); 265 (15.0%) participants were aged 18–34, 621 (35.3%) aged 35–54, and 876 (49.7%) aged more than 55. With regard to their education level, 8 (0.5%) participants reported having solely primary education or no schooling, 194 (11.0%) secondary education, 365 (20.7%) a bachelor's degree, and 678 (38.5%) a master's degree or a higher degree.[1]

We used longitudinal data collected in six waves over a period of eight months (see Table 1 for a data collection timetable for the entire sample). The survey was distributed every three weeks from April 1 until 2 July 2021, and remained open for each wave for eight days. In addition, we collected a last sample of data five months after the end of the main survey, on 25 November 2021. At the end of each questionnaire, participants were offered the possibility to take part in the next wave of data collection. Furthermore, new participants were recruited only during the first two waves. The proportion of participants who completed one or more waves and related information is available on the online supplementary material (see Figure S1). Participants were compensated for their time with gift lotteries at each wave of data collection and an additional gift lottery was performed for those who completed all the waves.

Missing values and dropout rates

In group-based trajectory modeling, missing data are most commonly handled *via* the Full Information Maximum Likelihood (FIML) method, and this was the methodology we used here (Jones et al., 2001; Nagin, 1999). Figure S1 reports the total number of waves of data collection completed per participant. Figures S2 and S3 report the attrition rate for the full sample and subsample, respectively (supplementary material).

Table 1. Timetable for six waves of data collected in 2021.

Waves	Starting date	End date	Intervals	*N*	% Women	Mean age
1	April 1	April 9	–	4112	56.9%	51.07 (14.96)
2	April 22	April 29	3 weeks	3047	59.7%	52.71 (15.08)
3	May 13	May 21	3 weeks	1835	62.0.%	53.24 (15.25)
4	June 3	June 11	3 weeks	1706	63.1%	53.61 (15.20)
5	June 24	July 2	3 weeks	1584	62.4%	53.25 (15.16)
6	November 25	December 2	5 months	1866	60.1%	54.68 (14.56)
Total	April 1	December 2	8 months	6026	57.4%	53.03 (14.97)

Note: The total represents the number of participants across all waves. Standard deviations for the variable age are presented in parentheses.

Measures

The questionnaire was divided into two sections. In the first section, participants responded to a series of psychological variables. In the second part of the questionnaire, they were asked to indicate their age, sex, nationality, province of residence, profession, education and to answer COVID-19 related questions including infected by COVID-19, vaccination intention, perceived consequences of being infected, and health anxiety. For the present study, we used the predictors (i.e. sociodemographic and psychological variables) collected at Wave 1, the four health behaviors collected from Wave 1 to Wave 5, and outcomes (loneliness and life satisfaction) collected at Wave 6, five months after the end of the main survey. All the items, correlations (Table S1) and means (Table S2) are available in the online supplementary material.

Health behaviors

Health behaviors in the COVID-19 literature are often assessed using single items which question the validity of each measure. The present research overcame this limitation and validated new measures by capturing numerous facets of each health behavior in many different social situations. To do so, we relied on multiple items for handwashing, mask wearing, limitations of social contact, and physical distancing by adapting scales based on previous studies (e.g. Bigot et al., 2021; Wollast et al., 2021), and from the guidelines of health institutions (e.g. WHO, CDC). Specifically, we relied on seven items for each health behavior including handwashing (e.g. 'I wash my hands before and after entering and leaving public places [public transportation, markets, places of worship, etc]'), mask wearing (e.g. 'I wear my mask when I walk outside with a friend'), limitations of social contact (e.g. 'I have almost zero in-person social interactions with people I am not living with') and physical distancing (e.g. 'I am careful to keep my physical distance from others, including even friends and family'). Participants rated the extent to which each statement applied to them using a 1 (*Totally disagree*) to 5 (*Totally agree*) response scale (for more information about the scale, see Wollast, Sadeghi-Bahmani et al., 2023).

To test whether the four health behaviors were distinct from each other, we performed confirmatory factor analyses on the full sample and compared several concurrent models. Model fit was assessed using multiple fit indices (Tanaka, 1993). The Root Mean Square Error of Approximation (*RMSEA*) should be ≤ .08, and the Comparative Fit Index (*CFI*) should be ≥ .90 (Hu & Bentler, 1999). The model was based on maximum likelihood estimation. *CFAs* indicated that the model distinguishing all health behaviors demonstrated greater model fit statistics, at each wave of data collection, than when we combined health behaviors together. To improve model fit, we allowed three within-factor error covariances (i.e. we included two correlated errors for physical distancing, and one for handwashing). Importantly, all standardized factor loadings were significant and above the conventional threshold (>.40). The selected model fit statistics at each timepoint are displayed in Table 2. Ultimately, McDonald's Omega coefficients were excellent for each of the health behaviors at each time of data collection (see Table 3).

Table 2. Four-factor model fit at each wave.

Waves	χ^2	*df*	*CFI*	*RMSEA*	Factor loadings
1	6530	341	.929	.066	.59–.88
2	5571	341	.925	.071	.59–.89
3	3860	341	.918	.075	.58–.90
4	4051	341	.911	.079	.60–.89
5	3685	341	.915	.079	.61–.89

Table 3. McDonald's Omega coefficient as a function of data collection timepoint.

Waves	Wave 1	Wave 2	Wave 3	Wave 4	Wave 5	Wave 6
Handwashing	.91	.92	.92	.92	.92	–
Mask wearing	.92	.93	.93	.93	.93	–
Social contact limitations	.89	.90	.90	.91	.91	–
Physical distancing	.91	.92	.92	.93	.94	–
Health anxiety	.71	–	–	–	–	–
Loneliness	–	–	–	–	–	.89
Life satisfaction	–	–	–	–	–	.89

Health anxiety

To measure worry about health, we used the back-translated items of Bigot et al. (2021) from the Whiteley Index (WI) developed by Pilowsky (1967). Specifically, these five items assess health anxiety (e.g. 'I'm afraid of getting sick') on a response scale ranging from 1 (*Totally disagree*) to 5 (*Totally agree*). McDonald's Omega coefficient demonstrated acceptable internal consistency (see Table 3).

Life satisfaction

Participants completed the Satisfaction With Life Scale (SWLS; Diener et al., 1985). The scale included five items (e.g. 'I am satisfied with my life', 'The conditions of my life are excellent', 'In most ways my life is close to my ideal'), from 1 (*Totally disagree*) to 5 (*Totally agree*), which demonstrated an excellent internal consistency (see Table 3).

Loneliness

We measured the proportion of respondents who reported feeling lonely during the COVID-19 pandemic using three items (e.g. 'I feel left out', 'I feel isolated from others', 'I feel abandoned') on a scale from 1 (*Totally disagree*) to 5 (*Totally agree*) response scale from Hughes et al. (2004). McDonald's Omega coefficient was excellent (see Table 3).

Statistical analysis

The statistical analyses were divided into five steps: (1) identifying independent trajectories of handwashing, mask wearing, limitations of social contact, and physical distancing (Hypothesis 1), (2) investigating the co-occurrence (i.e. associations) of these trajectories over time (Hypothesis 2), (3) identifying multi-trajectory groups for the four health behaviors considered simultaneously (versus individually as in step 1, Hypothesis 3), (4) highlighting sociodemographic variables and constructs related to COVID-19 distinguishing health behavior trajectories (Hypothesis 4) and (5) analyzing the associations between trajectory group membership and two outcomes related to mental health (i.e. loneliness and life satisfaction, Hypothesis 5). All statistical analyses were performed using RStudio (RStudio Team, 2021), SAS 9.4 (SAS Institute, Inc., Cary, NC, USA, 2016), and SPSS Statistics 26 (IBM Corp, 2019). Figure 3 summarizes the data analysis plan.

Identifying heterogeneity in latent trajectories

In a first step (Hypothesis 1), we used a group-based method to identify the trajectories for handwashing, mask wearing, limitation of social contacts, and physical distancing separately (Jones et al., 2001; Jung & Wickrama, 2008). Using finite mixtures of suitably defined probability distributions (Nagin, 1999), the group-based approach for multinomial modeling of trajectories is a method that identifies distinctive clusters of individual trajectories within the population and for profiling the characteristics of individuals within these clusters. Technically, the group-based trajectory model is an extension of the latent class model for longitudinal data and estimates their parameters by maximum likelihood using a Newton-Raphson optimization algorithm. We estimated from 1 to 4 latent classes (i.e. trajectories) for each health behavior independently and adjusted the shape of the trajectories which follows a polynomial function of time.

A key issue in finite mixture modeling is determining the adequate number of trajectory groups and their shape for the best fitting model. Following the recommendations of D'Unger et al. (1998), we used the Bayesian Information Criterion (BIC) as a basis for selecting the optimal model, with BIC closer to zero indicating a better model fit. Based on the selected model, this procedure assigns people into trajectory groups based on the maximum posterior probability. Ultimately, because the four health behaviors were continuous with approximately normal distributions with some censoring at the extreme scores of the scale (i.e. 1 and 5), we modeled them using a censored normal distribution (CNORM).

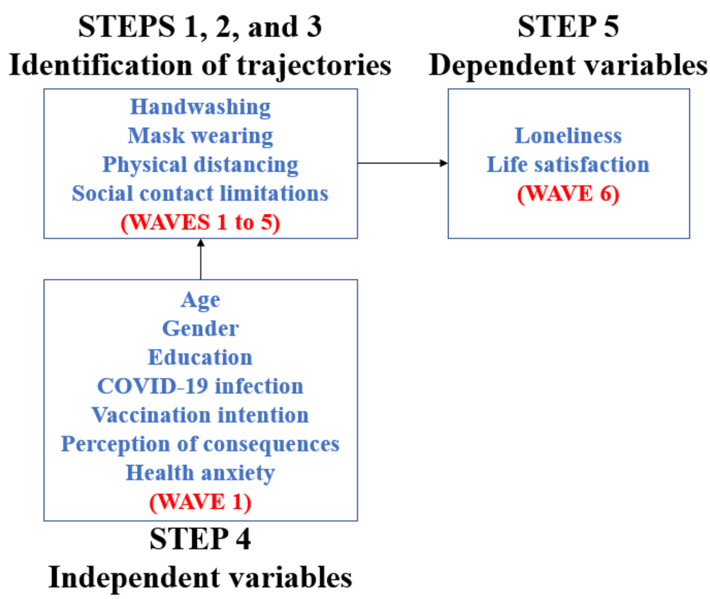

Figure 3. Data analysis plan.

Co-occurrence using joint latent trajectories

Step 2 involved testing the conditional probability of individuals belonging to specific trajectory groups on one specific health behavior to be assigned to similar groups on the three other health behaviors (Hypothesis 2). Because we relied on four health behaviors, we conducted six paired analyses so that each health behavior is compared with the three other ones.

Identifying multi-trajectory groups

After assigning individuals into different trajectory groups (step 1) and confirming that these different trajectory groups were strongly and positively associated with each other (step 2), in step 3 we identified groups of multiple trajectories. While step 1 identified clusters of participants for each health behavior separately, the multi-trajectory approach identified groups of individuals that followed similar patterns across the four health behaviors considered simultaneously. We expected that when handwashing, mask wearing, limitations of social contact, and physical distancing were considered jointly in the same multi-trajectory model, trajectories would follow the same pattern as observed in our first step (Hypothesis 3).

Multi-trajectory is a generalization of group-based trajectory modeling which allowed us to take full advantage of the information available in multivariate longitudinal data for tracking the course of health behaviors (Nagin et al., 2018). While group-based trajectory modeling is designed to identify clusters of individuals who are following similar trajectories of a single indicator of interest (step 1 and step 2), multi-trajectory modeling identifies latent clusters of individuals following similar trajectories across multiple indicators (e.g. handwashing, mask wearing, limitation of social contacts and physical distancing) of an outcome of interest (e.g. health behavior adherence). These multi-trajectory group membership designations enabled us to create groups with different levels of overall adherence displayed during the COVID-19 period. Consequently, the percentage of participants belonging to specific multi-trajectory groups of health behavior adherence was the same for each health behavior (step 3), whereas this percentage varied between behaviors in the first group-based trajectory modeling approach (step 1 and step 2).

Associations between trajectories and sociodemographic and psychological factors

In step 4, we used the RISK function of PROC TRAJ from SAS to analyze sociodemographic risk factors (i.e. age, gender, education) and constructs related to COVID-19 (e.g. COVID-19 infection status) to identify those that could differentiate health behavior trajectories, using low levels of adherence as a reference category (Hypothesis 4).

Associations between trajectories and mental health outcomes

In step 5 (Hypothesis 5), using two independent univariate ANOVA, we analyzed the relation between health behavior adherence trajectories and two mental health indicators including loneliness and life satisfaction. In addition, to compare group means, we relied on post-hoc comparisons using Tukey's HSD with Games Howell's correction.

Results

Identification of health behavior trajectories

To address this first goal, we identified the number and the shape of trajectories for handwashing, mask wearing, limitations of social contact, and physical distancing, from wave one (1 April 2021) to wave five (24 June 2021), separately. Table 4 reports *BIC* scores for models with a varying number of groups (i.e. trajectories) and trajectory shapes within each group. Based on the *BIC* criterion (e.g. closer to zero), a four-group model was selected as the best fitting model for each of the four health behaviors. Figure 4 depicts the patterns of the trajectories for each health behavior as well as their respective confidence intervals (i.e. 95% CIs).

In line with Hypothesis 1, the four identified trajectories followed low (red), moderate-low (green), moderate-high (blue) and high (black) levels of adherence to handwashing, mask wearing, limitations of social contact, and physical distancing. More specifically, and as expected for each behavior, a distinct cluster of individuals

Table 4. Bayesian information criterion (BIC) for selection of models.

	Model	*K*	Behavior	Order	BIC
Trajectories of handwashing (HW), mask wearing (MW), limitation of social contacts (LSC), and physical distancing (PD), analyzed separately (Steps 1 and 2)	1	2	HW	3, 3	−8720.01
	2	3	HW	3, 3, 3	−7461.78
	3	4	HW	3, 3, 3, 3	−6948.53
	4	**4**	**HW**	**1, 1, 1, 1**	**−6925.13**
	1	2	MW	3, 3	−9283.50
	2	3	MW	3, 3, 3	−8242.66
	3	4	MW	3, 3, 3, 3	−7703.60
	4	**4**	**MW**	**1, 2, 2, 2**	**−7688.89**
	1	2	LSC	3, 3	−8268.15
	2	3	LSC	3, 3, 3	−7325.63
	3	4	LSC	3, 3, 3, 3	−6817.01
	4	**4**	**LSC**	**1, 2, 2, 2**	**−6802.47**
	1	2	PD	3, 3	−8950.34
	2	3	PD	3, 3, 3	−7876.53
	3	4	PD	3, 3, 3, 3	−7276.05
	4	**4**	**PD**	**1, 2, 2, 2**	**−7258.22**
	Model	*K*	Behavior	Order	BIC
Multi-trajectories of the four health behaviors analyzed jointly (Step 3)	1	2	HW	3, 3	−35765.52
			MW	3, 3	
			LSC	3, 3	
			PD	3, 3	
	2	3	HW	3, 3, 3	−32389.41
			MW	3, 3, 3	
			LSC	3, 3, 3	
			PD	3, 3, 3	
	3	4	HW	3, 3, 3, 3	−30677.38
			MW	3, 3, 3, 3	
			LSC	3, 3, 3, 3	
			PD	3, 3, 3, 3	
	4	**4**	**HW**	**1, 1, 1, 1**	**−30606.04**
			MW	**2, 2, 2, 2**	
			LSC	**1, 2, 2, 2**	
			PD	**1, 2, 2, 2**	

Note: *K* = Number of groups (trajectories). The order indicates whether the trajectory was fit with a constant (0), linear (1), quadratic (2), or cubic (3) function. HW = Handwashing, MW = Mask wearing, LSC = Limitation of social contacts, PD = Physical distancing. For each *k* level, we tested all model combinations possible including all different polynomial functions. For clarity, we only report the most relevant models (baseline model and best model for each *k* level).

demonstrated a persistently high level of adherence. This high adherence trajectory group comprised 33.4% (handwashing), 33.3% (mask wearing), 26.6% (limitations of social contact), and 26.9% (physical distancing) of the sample, and was characterized by a negative quadratic function (negative linear for handwashing, see Table 4), suggesting that a majority of participants had high levels of adherence, which also slightly decreased over time (see Figure 4).

A similar pattern emerged for individuals demonstrating a persistently low level of adherence, comprised 10.7% (handwashing), 11.7% (mask wearing), 12.2% (limitations of social contact), and 11.8% (physical distancing) of the sample. It was characterized by a negative linear function for each health behavior (see Table 4), suggesting that individuals who had low levels of adherence also experienced a similar decrease over time (see Figure 4).

Ultimately, the moderate-low and moderate-high adherence trajectory groups contained the vast majority of participants (i.e. more than 55%). As for the low and high clusters described above, the moderate trajectories for each behavior demonstrated only negative estimates and declining shapes (linear and quadratic functions, see Table 4). Taken together, these results indicated that the average levels of adherence to handwashing, mask wearing, limitations of social contact, and physical distancing decreased over time, regardless of the initial adherence level.

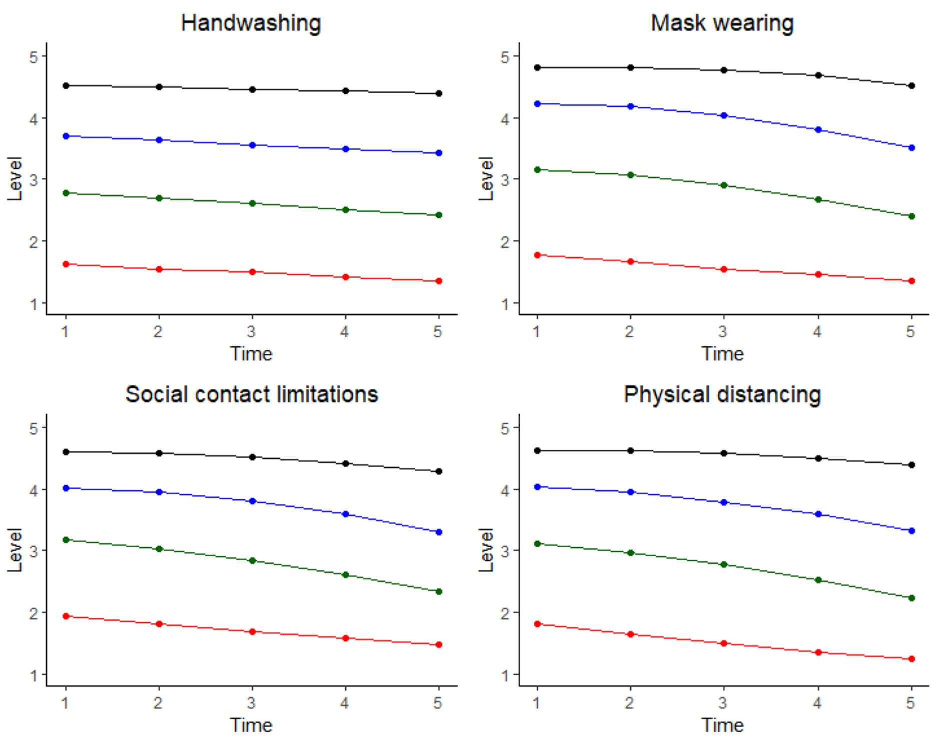

Figure 4. Trajectories for the four health behaviors that followed low (red; HW = 10.7%, MW = 11.7%, LSC = 12.2%, PD = 11.8%), moderate-low (green; HW = 19.3%, MW = 21.0%, LSC = 22.8%, PD = 21.3%), moderate-high (blue; HW = 36.6%, MW = 34.1%, LSC = 39.9%, PD = 38.5%), and high (black; HW = 33.4%, MW = 33.3%, LSC = 26.6%, PD = 26.9%) levels from April 1 to July 2, 2021. The x-axis (horizontal line) represents the five waves of data collection whereas the y-axis (vertical line) represents the five levels of the health behaviors response scale. Model fit statistics can be found in Table 4.

Conditional probabilities of co-occurrence

Next, we examined the co-occurrence of the trajectory groups of the four health behaviors identified in step 1. Table 5 reports the conditional probabilities of belonging to a specific trajectory group conditional to one of the three other ones. In line with Hypothesis 2, the trajectories of physical distancing, limitations of social contact, and mask wearing were strongly associated, suggesting that these three avoidant health behaviors tended to follow a comparable course over time. Specifically, the large diagonal elements of the probability matrices (in bold in Table 5) indicated that there was considerable overlap between these trajectories. For instance, the majority of individuals who followed the highest level of adherence to physical distancing also followed the highest level of adherence to limitation of social contacts (90.8%) and mask wearing (78.5%). As expected, a similar pattern emerged for the lowest levels of adherence. Additionally, and in line with our hypotheses, these associations are significant but weaker for handwashing, the only classical health behavior.

Multi-trajectory groups of health behaviors

Once step 1 and step 2 were successfully conducted, we identified multi-trajectory groups by considering all health behaviors in the same model simultaneously (Nagin et al., 2018). Following the multi-trajectory approach, four latent classes of trajectories were identified: low (11.9%), moderate-low (20.9%), moderate-high (39.1%) and high (28.1%) levels of health behavior adherence. Patterns of the trajectories and mean posterior assignment probabilities are detailed in the online supplementary material. Remarkably, the best fitting model demonstrated that trajectories of the four health behaviors considered jointly followed the exact same pattern than when they were treated independently (see Figure S1). In line with Hypothesis 3, these results indicated that the four health behaviors considered simultaneously manifested similarly as when they were treated separately (see Table 4).

Factors associated with trajectory groups

Trajectory analysis assumes heterogeneity in a sample where unobserved homogeneous sub-populations exist (Nagin, 1999). Specifically, we found that the four health behaviors decreased over time among Belgian participants. However, within such a population, there were subgroups with different levels of adherence, although their slopes tended to follow a similar pattern of declination over time. In step 4 (Hypothesis 4), we explored whether the trajectory membership probabilities for the reference category (i.e. low levels for the four health behavior trajectory groups) could be distinguished from other trajectory groups as a function of sociodemographic and psychological factors.

Tables 6, 7, 8, and 9 report the factors associated with the probability of group membership as a function of trajectory groups for handwashing, mask wearing, social contact limitations, and physical distancing.

Table 5. Co-occurrence of the four health behaviors.

Group	Low	Moderate-low	Moderate-high	High
Probability of handwashing groups conditional on mask wearing groups				
High handwashing	2.7%	6.8%	23.4%	67.2%
Moderate-high handwashing	9.7%	35.4%	55.4%	27.3%
Moderate-low handwashing	29.9%	44.1%	18.0%	3.8%
Low handwashing	57.7%	13.7%	3.2%	1.7%
Probability of handwashing groups conditional on limitations of social contact groups				
High handwashing	2.7%	13.6%	33.1%	65.5%
Moderate-high handwashing	18.0%	38.2%	46.4%	28.4%
Moderate-low handwashing	33.6%	33.2%	16.9%	4.0%
Low handwashing	45.7%	15.0%	3.6%	2.1%
Probability of handwashing groups conditional on physical distancing groups				
High handwashing	3.9%	12.6%	33.4%	66.5%
Moderate-high handwashing	14.1%	42.1%	48.2%	25.4%
Moderate-low handwashing	34.1%	32.8%	14.4%	6.2%
Low handwashing	47.9%	12.5%	4.0%	1.9%
Probability of mask wearing groups conditional on limitations of social contact groups				
High mask wearing	0.1%	1.7%	23.6%	85.3%
Moderate-high mask wearing	1.9%	27.8%	63.0%	14.2%
Moderate-low mask wearing	24.6%	60.0%	13.0%	0.5%
Low mask wearing	73.4%	10.5%	0.4%	0.0%
Probability of mask wearing groups conditional on physical distancing groups				
High mask wearing	0.0%	2.1%	17.0%	78.5%
Moderate-high mask wearing	1.4%	30.2%	65.2%	19.7%
Moderate-low mask wearing	21.4%	56.3%	17.2%	1.8%
Low mask wearing	77.2%	11.4%	0.6%	0.0%
Probability of limitations of social contact groups conditional on physical distancing groups				
High social contact limitations	0.0%	0.4%	7.7%	90.8%
Moderate-high social contact limitations	0.0%	13.8%	86.3%	9.2%
Moderate-low social contact limitations	7.1%	80.1%	6.0%	0.0%
Low social contact limitations	92.9%	5.7%	0.0%	0.0%

For the variable age, the larger the gap between trajectory groups was, the greater the absolute estimation was observed (i.e. for social contact limitations: 0.01 for low vs. moderate-low and 0.04** for low vs. high). In line with Hypothesis 4, older people had a higher probability of belonging to the highest trajectory groups of social contact limitations and physical distancing, as compared to younger people. However, this effect was not significant for mask wearing and handwashing. Further, and in line with Hypothesis 4, women's probability of belonging to high trajectories of each health behavior was significantly greater than men (Women = 0; Men = 1). Regarding education, we found that more educated people had a higher probability of belonging to the lowest trajectory groups of social contact limitations and physical distancing, and no significant effects were observed for mask wearing and handwashing.

Turning now to variables related to the COVID-19 pandemic, and as expected, individuals who had been previously infected by COVID-19 had a higher probability of belonging to the highest health behavior trajectory groups. In addition, and consistent with Hypothesis 4, people with positive vaccination intention, higher perceived consequences, and greater health anxiety, had a higher probability of belonging to the highest health behavior trajectory groups.

Table 6. Factors associated with the probability of group membership as a function of trajectory groups for handwashing.

	Parameter	Estimate	Standard error	T for H0	Prob > |T|
Low (Reference category)	–	–	–	–	–
Low vs. Moderate Low	Constant	−0.24178	1.05759	−0.229	0.8192
	Age	−0.00560	0.01056	−0.530	0.5960
	Gender	−0.41361	0.28191	−1.467	0.1424
	Education	−0.06169	0.18620	−0.331	0.7404
	Had COVID-19	0.08439	0.11075	0.762	0.4461
	Vaccination intention	**0.23464**	**0.09650**	**2.432**	**0.0151**
	Consequences	−0.20951	0.17175	−1.220	0.2226
	Health anxiety	**0.44521**	**0.20369**	**2.186**	**0.0289**
Low vs. Moderate High	**Constant**	**−3.43165**	**0.92146**	**−3.724**	**0.0002**
	Age	0.00613	0.00948	0.647	0.5177
	Gender	**−0.75987**	**0.25911**	**−2.933**	**0.0034**
	Education	0.10471	0.16514	0.634	0.5261
	Had COVID-19	**0.25470**	**0.10293**	**2.474**	**0.0134**
	Vaccination intention	**0.52782**	**0.09412**	**5.608**	**0.0000**
	Consequences	0.06491	0.15469	0.420	0.6748
	Health anxiety	**0.81664**	**0.18292**	**4.464**	**0.0000**
Low vs. High	**Constant**	**−3.24884**	**0.92817**	**−3.500**	**0.0005**
	Age	−0.00503	0.00967	−0.520	0.6031
	Gender	**−1.56191**	**0.27297**	**−5.722**	**0.0000**
	Education	−0.13254	0.16796	−0.789	0.4301
	Had COVID-19	**0.31948**	**0.10679**	**2.992**	**0.0028**
	Vaccination intention	**0.51060**	**0.09802**	**5.209**	**0.0000**
	Consequences	**0.41711**	**0.15888**	**2.625**	**0.0087**
	Health anxiety	**0.95635**	**0.18578**	**5.148**	**0.0000**

Table 7. Factors associated with the probability of group membership as a function of trajectory groups for mask wearing.

	Parameter	Estimate	Standard error	T for H0	Prob > |T|
Low (Reference category)	–	–	–	–	–
Low vs. Moderate Low	Constant	−1.32345	0.91853	−1.441	0.1497
	Age	−0.00886	0.00987	−0.897	0.3696
	Gender	**−0.80188**	**0.27666**	**−2.898**	**0.0038**
	Education	−0.30673	0.17737	−1.729	0.0838
	Had COVID-19	0.05744	0.10773	0.533	0.5939
	Vaccination intention	**0.63389**	**0.09552**	**6.636**	**0.0000**
	Consequences	0.32727	0.17612	1.858	0.0632
	Health anxiety	0.27223	0.19015	1.432	0.1523
Low vs. Moderate High	**Constant**	**−4.46264**	**0.95387**	**−4.678**	**0.0000**
	Age	0.00569	0.00985	0.578	0.5632
	Gender	**−0.95946**	**0.27290**	**−3.516**	**0.0004**
	Education	−0.23902	0.17636	−1.355	0.1754
	Had COVID-19	0.09260	0.10793	0.858	0.3909
	Vaccination intention	**0.79624**	**0.09863**	**8.073**	**0.0000**
	Consequences	**0.66597**	**0.17400**	**3.827**	**0.0001**
	Health anxiety	**0.67730**	**0.18579**	**3.645**	**0.0003**
Low vs. High	**Constant**	**−5.74135**	**0.99189**	**−5.788**	**0.0000**
	Age	0.00923	0.01010	0.914	0.3608
	Gender	**−1.03785**	**0.28225**	**−3.677**	**0.0002**
	Education	−0.33264	0.18097	−1.838	0.0661
	Had COVID-19	**0.22608**	**0.11244**	**2.011**	**0.0444**
	Vaccination intention	**0.77494**	**0.10393**	**7.456**	**0.0000**
	Consequences	**1.09581**	**0.17981**	**6.094**	**0.0000**
	Health anxiety	**0.70506**	**0.19073**	**3.697**	**0.0002**

Table 8. Factors associated with the probability of group membership as a function of trajectory groups for social contact limitations.

	Parameter	Estimate	Standard error	T for H0	Prob > |T|
Low (Reference category)	–	–	–	–	–
Low vs. Moderate Low	**Constant**	**−2.78275**	**0.95081**	**−2.927**	**0.0034**
	Age	0.01300	0.01047	1.241	0.2146
	Gender	**−0.89562**	**0.28385**	**−3.155**	**0.0016**
	Education	−0.20042	0.19107	−1.049	0.2943
	Had COVID-19	0.16074	0.11031	1.457	0.1452
	Vaccination intention	**0.54823**	**0.09739**	**5.629**	**0.0000**
	Consequences	0.30679	0.18504	1.658	0.0974
	Health anxiety	**0.52571**	**0.20254**	**2.596**	**0.0095**
Low vs. Moderate High	**Constant**	**−5.00502**	**0.95170**	**−5.259**	**0.0000**
	Age	**0.03053**	**0.01007**	**3.031**	**0.0025**
	Gender	**−0.87458**	**0.27576**	**−3.172**	**0.0015**
	Education	**−0.36170**	**0.18218**	**−1.985**	**0.0472**
	Had COVID-19	**0.30401**	**0.10891**	**2.791**	**0.0053**
	Vaccination intention	**0.74104**	**0.09973**	**7.431**	**0.0000**
	Consequences	**0.81858**	**0.18012**	**4.545**	**0.0000**
	Health anxiety	**0.63347**	**0.19722**	**3.212**	**0.0013**
Low vs. High	**Constant**	**−6.52751**	**1.04782**	**−6.230**	**0.0000**
	Age	**0.04447**	**0.01094**	**4.064**	**0.0000**
	Gender	**−1.31064**	**0.30465**	**−4.302**	**0.0000**
	Education	**−0.68817**	**0.19447**	**−3.539**	**0.0004**
	Had COVID-19	**0.24934**	**0.11852**	**2.104**	**0.0355**
	Vaccination intention	**0.72671**	**0.11266**	**6.451**	**0.0000**
	Consequences	**1.22279**	**0.19253**	**6.351**	**0.0000**
	Health anxiety	**0.81328**	**0.20941**	**3.884**	**0.0001**

Table 9. Factors associated with the probability of group membership as a function of trajectory groups for physical distancing.

	Parameter	Estimate	Standard error	T for H0	Prob > |T|
Low (Reference category)	–	–	–	–	–
Low vs. Moderate Low	**Constant**	**−3.17827**	**0.97966**	**−3.244**	**0.0012**
	Age	0.01123	0.01037	1.083	0.2789
	Gender	**−0.93899**	**0.28690**	**−3.273**	**0.0011**
	Education	−0.03358	0.18855	−0.178	0.8587
	Had COVID-19	0.02138	0.10996	0.194	0.8459
	Vaccination intention	**0.46307**	**0.09571**	**4.838**	**0.0000**
	Consequences	**0.46370**	**0.18911**	**2.452**	**0.0142**
	Health anxiety	**0.48926**	**0.19930**	**2.455**	**0.0141**
Low vs. Moderate High	**Constant**	**−5.11041**	**0.96139**	**−5.316**	**0.0000**
	Age	0.01399	0.01001	1.398	0.1621
	Gender	**−0.86570**	**0.27669**	**−3.129**	**0.0018**
	Education	−0.17388	0.17983	−0.967	0.3337
	Had COVID-19	**0.21663**	**0.10934**	**1.981**	**0.0476**
	Vaccination intention	**0.73863**	**0.09972**	**7.407**	**0.0000**
	Consequences	**0.94749**	**0.18491**	**5.124**	**0.0000**
	Health anxiety	**0.61229**	**0.19323**	**3.169**	**0.0015**
Low vs. High	**Constant**	**−5.90393**	**1.02845**	**−5.741**	**0.0000**
	Age	**0.02369**	**0.01069**	**2.215**	**0.0268**
	Gender	**−1.34372**	**0.30384**	**−4.422**	**0.0000**
	Education	**−0.54821**	**0.18983**	**−2.888**	**0.0039**
	Had COVID-19	**0.26015**	**0.11979**	**2.172**	**0.0299**
	Vaccination intention	**0.64497**	**0.10870**	**5.933**	**0.0000**
	Consequences	**1.34621**	**0.19727**	**6.824**	**0.0000**
	Health anxiety	**0.78288**	**0.20388**	**3.840**	**0.0001**

Associations between trajectory groups and mental health outcomes

To reach our fifth goal, we used two univariate ANOVA to analyze the associations between trajectory groups and loneliness and life satisfaction. Table 10 reports the means, standard deviations, and post-hoc Tukey's tests with Games Howell's correction for both variables as a function of trajectory groups. In line with Hypothesis 5, we evidenced that individuals belonging to trajectories of high levels of adherence to social contact limitations and physical distancing experienced higher loneliness (Social contact limitations: $F[3,1127] = 4.02$, p = .006, Partial η^2 = .011; Physical distancing: $F[3,1127] = 6.35$, p = .000, Partial η^2 = .017) and lower life satisfaction (Social contact limitations: $F[3,1127] = 3.08$, p = .027, Partial η^2 = .008; Physical distancing: $F[3,1127] = 3.67$, p = .012, Partial η^2 = .010). Additionally, and in partial support of Hypothesis 5, we found that neither handwashing nor mask wearing were associated with loneliness (Handwashing: $F[3,1127] = 1.63$, p = .181, Partial η^2 = .004; Mask wearing: $F[3,1127] = 1.06$, p = .367, Partial η^2 = .003), nor life satisfaction (Handwashing: $F[3,1127] = 1.82$, p = .142, Partial η^2 = .005; Mask wearing: $F[3,1127] = 1.33$, p = .265, Partial η^2 = .004). Ultimately, we repeated all analyses while controlling for age and gender, and successfully reproduced the findings.

Table 10. Means, standard deviations and Tukey's HSD tests for loneliness and life satisfaction as a function of trajectory groups.

	Loneliness	Life satisfaction
Low *handwashing*	2.18^{a} (1.12)	3.41^{a} (0.90)
Moderate-low	2.28^{a} (1.12)	3.31^{a} (0.78)
Moderate-high	2.26^{a} (1.11)	3.38^{a} (0.80)
High	2.40^{a} (1.17)	3.26^{a} (0.87)
Low *mask wearing*	2.18^{a} (1.13)	3.34^{a} (0.86)
Moderate-low	2.27^{a} (1.16)	3.37^{a} (0.78)
Moderate-high	2.29^{a} (1.08)	3.37^{a} (0.81)
High	2.37^{a} (1.17)	3.26^{a} (0.86)
Low *limitation of social contacts*	**2.04^{a} (1.07)**	3.42^{a} (0.82)
Moderate-low	**$2.23^{a, b}$ (1.13)**	3.32^{a} (0.82)
Moderate-high	2.32^{b} (1.08)	3.38^{a} (0.78)
High	2.44^{b} (1.13)	**3.22^{b} (0.91)**
Low *physical distancing*	**2.04^{a} (1.06)**	3.38^{a} (0.82)
Moderate-low	**2.14^{a} (1.04)**	3.45^{a} (0.75)
Moderate-high	2.36^{b} (1.11)	**$3.31^{a, b}$ (0.82)**
High	2.45^{b} (1.24)	**3.23^{b} (0.90)**

Note: Standard deviations are presented in parentheses. Means with differing superscripts (^{a} and ^{b}) within columns are significantly different at the $p < .05$ using Tukey's HSD test with Games Howell's correction and refer to differences between trajectory groups. Significant differences are highlighted in bold.

Discussion

This study investigated the trajectories of handwashing, mask wearing, social contact limitations, and physical distancing using numerous waves of data in a large sample of Belgian residents during the COVID-19 pandemic. In line with our hypotheses, we identified groups of individuals following low, moderate-low, moderate-high, and high trajectories of health behaviors over time (Hypothesis 1), observed a considerable overlap between these trajectories (Hypothesis 2), found a similar longitudinal pattern when the four health behaviors were considered simultaneously (Hypothesis 3), and highlighted associations with sociodemographic variables, constructs related to COVID-19 (Hypothesis 4), and mental health indicators (Hypothesis 5).

Trajectories of health behaviors

In line with our hypotheses, and consistent with other studies (e.g. Courdi et al., 2023; MacNeil et al., 2022), the results of this longitudinal research evidenced four distinct (Hypothesis 1) and joint (Hypothesis 3) trajectories that demonstrated variations between individuals in their levels of handwashing, mask wearing, social contact limitations, and physical distancing. First, while the majority of individuals aggregated between moderate-high (39.1%) and high (28.1%) levels of health behavior adherence, a significant number of people reported low (11.9%) and moderate-low (20.9%) levels over time. These findings suggest that adopting such radical behavior change within a few days and for a long period of time is notoriously challenging. Second, all trajectories were characterized by declining shapes (linear or quadratic) indicating that levels of adherence decreased over time for everyone. This came as no surprise since the epidemiologic situation in Belgium improved during the second wave of data collection (see Figures 1 and 2), which may have led to a decrease in participants' health anxiety and fear of infection, or the possibility that people may have been tired of following restrictive governmental measures. Interestingly, a similar pattern of gradual reduction in adherence to protective behaviors against COVID-19 was also observed in other studies covering different periods of time (e.g. Petherick et al., 2021). For instance, MacNeil et al. (2022) identified four trajectories of physical distancing during the first two waves of the COVID-19-pandemic (from April 2020 to October 2020): a high-adherence trajectory, a slow-declining trajectory, a fluctuating trajectory, and a fast-declining trajectory. Specifically, and consistent with our findings, they observed an overall declining adherence to physical distancing over an eight-month period starting at the beginning of the first wave of COVID-19 cases. They concluded that the most important predictors of non-adherence include perceptions of low self-efficacy and high barriers to adherence, as well as lower prosocial attitudes towards physical distancing.

In line with Hypothesis 2, we found strong positive associations among the four health behaviors trajectories, indicating that participants who adopted a specific health behavior over time were more likely to adhere to the three others as well. As expected, these associations were significant but weaker for handwashing. These findings were expected given that limiting social contacts by staying home, respecting physical distancing in public places, and face coverings are avoidant behaviors (Bish & Michie, 2010), which have a psychological cost, whereas handwashing is a non-avoidant protective health behavior (Pogrebna & Kharlamov, 2020). Note however that communication campaigns also encouraged people to not shake hands anymore, which can be considered as an avoidant behavior, but this level of behavioral avoidance was minor compared to fundamental behaviors such as the need for social contacts and togetherness.

One goal of the present work was to better understand which factors can facilitate or hinder the adoption of these health behaviors over time. To do so, we explored the role sociodemographic and psychological factors play in the application of health behaviors over time.

Sociodemographic and psychological differences in health behaviors

In line with Hypothesis 4, the present study shows that women's probability to belong to high trajectories of health behaviors adherence was significantly higher than men. This is consistent with previous findings showing that women engage more often than men in handwashing (White et al., 2020) and mask wearing (Cassino & Besen-Cassino, 2020), as well as in social and physical distancing (Guo et al., 2021). These gender differences may often be associated with how masculinity is perceived among men (Cassino & Besen-Cassino, 2020). Indeed, wearing a face mask can be perceived by men as a sign of fragility and weakness, or as an infringement on their independence and sense of freedom (Capraro & Barcelo, 2020; Howard, 2021). It is therefore important to understand the perception of these health behaviors through the lens of gender identities.

Further, we found that younger people had a higher probability to belong to low social contact limitations and physical distancing trajectory groups while older people had a higher probability to belong to high trajectories. This is consistent with previous findings showing that young people adhered less frequently to sanitary rules (e.g. Bigot et al., 2021; Canning et al., 2020; Hart & Opielinski, 2020). In this regard, we found that younger people perceived themselves to be at lower risk of severe illness from COVID-19 compared to older adults. Since older individuals were generally more susceptible to serious complications and mortality from the virus, they may have been more motivated to strictly follow social distancing guidelines. In addition, younger individuals often have more active social lives and may prioritize socializing, gathering with friends, and participating in events. The desire for social interaction and the need to maintain social connections may have led some younger people to be less inclined to follow social distancing guidelines. In addition, over time, individuals may have experienced fatigue or frustration due to the prolonged nature of the pandemic and the associated restrictions. Younger people, who may have experienced a larger disruption to their routines and social lives, might have been more likely to have felt fatigued and become less adherent to social distancing measures.

Finally, and consistent with previous findings (Bigot et al., 2021; Schmitz et al., 2022a, 2022b), we found that individuals who had been previously infected by COVID-19 had a higher probability of belonging to the highest health behavior trajectory groups. In addition, people with positive vaccination intention, higher perceived consequences of being infected, and greater health anxiety, had a higher probability of belonging to the highest health behavior trajectory groups. This aligns with the findings from Wollast et al. (2021) who successfully demonstrated that adherence to health behaviors was strongly associated with positive attitudes related to sanitary practices. In the same vein, we extended Bigot et al. (2021)'s finding who observed associations between negative emotions and health behaviors. Specifically, they found that scoring higher on health anxiety (also called hypochondria) was related to a higher frequency of adherence to handwashing.

Taken together, these results suggest that public health recommendations should have particularly focused on young men as well as specific clusters of individuals (e.g. those who had negative attitudes towards vaccination, Enea et al., 2023) and be adapted in light of the subjective representations and meanings that health behaviors generate among those people.

Health behaviors and mental health

The COVID-19 pandemic has had significant psychological and social effects on the population (Saladino et al., 2020; Salari et al., 2020). Quarantine, isolation, and distancing were most effective strategies for preventing the first and secondary transmission of the disease as compared to handwashing and mask wearing (Shah et al., 2020, see also Talic et al., 2021), but they had the worse detrimental impact on mental health. Indeed, many studies observed depressed levels of emotional well-being (Wollast, Preece, Schmitz, et al., 2023), high levels of negative emotions (Gamonal-Limcaoco et al., 2022) and clinical levels of depression, anxiety, and stress (Tso & Park, 2020) during the COVID-19 crisis. In line with Hypothesis 5, the present study demonstrates that trajectory groups with higher levels of social contact limitations and physical distancing were associated with greater loneliness and lower life satisfaction. Importantly, these associations were not significant for handwashing and mask wearing. These findings highlight that social distancing guidelines often required individuals to limit face-to-face interactions, avoid crowded places, and maintain physical distance from others. These restrictions can lead to a significant reduction in social interactions, particularly for individuals who live alone or have limited social support networks. Adopting social distancing rules can disrupt these support networks, making it more difficult to seek comfort, advice, or assistance from family, friends, or community members. Similarly, social distancing measures may alter regular routines and activities that provide a sense of purpose, fulfillment, and social connection. Closure of social venues, cancellation of events and gatherings, and remote work or study arrangements can leave individuals feeling disconnected and unengaged. The resulting isolation and lack of regular social contact can contribute to feelings of loneliness and decreased life satisfaction.

As lockdowns took effect in cities around the world, many studies observed high levels of loneliness (Killgore et al., 2020), social isolation (Banerjee & Rai, 2020), and emotional distancing (Mohindra et al., 2021) during the COVID-19 pandemic. While public health recommendations encouraging limitation of social contacts and physical distancing were necessary to reduce the spread of COVID-19, they could also make people feel isolated and lacking social support, which can generate negative psychological consequences such as increased loneliness and lower life satisfaction. More precisely, social contact limitations and physical distancing are challenging as they push individuals against their deep instinct for togetherness for many individuals (Pfefferbaum & North, 2020; Rajkumar, 2020). The present work supports the adherence of handwashing and mask coverings as first health behavior measures because they have positive epidemiological effects and reduce mental health consequences, as compared to social contact limitations and physical distancing. In sum, although health behaviors have been widely encouraged across the globe to overcome COVID-19, more attention should be given to the mental health consequences each of them may entail.

Limitations

Although this study expands our understanding of how handwashing, mask wearing, social contact limitations, and physical distancing manifest over time, this study is not without limitations. First, each wave of data collection included mostly adults with higher levels of education, which limits the generalizability of the results. In the same vein, some categories (e.g. young men following the high health behaviors adherence trajectory) contained a limited number of participants which can also affect generalizability. Second, although a large number of people responded to the surveys, the results cannot be considered representative of the entire Belgian population. The main reason for this is that participation was based on a decision by the respondents which results in self-selection explained by situational, psychological or socio-demographic elements. Respondents were, for example, people with a computer, tablet or smartphone and an internet connection, with time, with an interest in (aspects of) health policy related to COVID-19, with a motivation to complete the surveys, with a certain position in favor or against certain measures, with an understanding of the questions asked, and so on. Third, and contrary to our hypotheses, we did not observe age differences for handwashing and mask wearing. However, it is worth mentioning that when considering age separately from other variables, we found significant differences for all health behaviors, which aligns with other studies (Bigot et al., 2021). Fourth, the epidemiological situation evolved worldwide, and new health behaviors appeared as crucial such as ventilation. Recommendations regarding ventilation suggested that masks became crucial when meeting in spaces with little ventilation. However, this aspect was only indirectly measured ('I wear my mask when I am with people who are not my close contacts in a room with poor or unknown ventilation') in the present study. This also reminds us that respecting certain behaviors can have different effects depending on the context (e.g. outside vs. inside). Fifth, the current longitudinal study only captures the end of the third peak in Belgium (from 1 April to 2 December 2021). Consequently, we encourage scholars to explore longitudinal samples from other countries using representative samples of the population to replicate our findings.

Implications and future directions

Research examining health behaviors during the COVID-19 pandemic from a longitudinal perspective is necessary. Associations found in the present study enrich the current literature and suggest implications for research and practice.

Research

The existing literature often relies on single items to measure health behaviors, which does not adequately assess each construct. The present work overcame this limitation and successfully validated robust measures of handwashing, mask wearing, social contact limitations, and physical distancing (see all items in the online supplementary material). Each of these seven-item scales captures numerous different social situations (e.g. outside vs. inside) which have been strongly supported by model fit statistics.

Additionally, most of the studies on health behaviors have only been tested using cross-sectional data (e.g. Wollast et al., 2021). Our research strengthens and deepens previous findings by relying on a person-oriented longitudinal method to explain the interindividual variations in intraindividual change. To characterize heterogeneity of health behaviors, we conducted a latent class growth analysis to identify homogeneous subgroups of health behavior adherence trajectories within the larger heterogeneous population (Nagin et al., 2018). This approach was selected because it provides unique insight to detect changes in the characteristics of the target population over time, which increases the validity of the data and makes it easier to find long-term patterns. More precisely, this modeling technique effectively captures the complexity of longitudinal patterns by identifying clusters of individuals with similar trajectories of outcomes over time (Nagin, 2010). This flexible approach has the advantage of allowing one to map differences not only of the average within a group, but the different trajectories within a group. This enables the exploration of hidden heterogeneity, allowing for tailored support among vulnerable groups (i.e. individuals with low levels of adherence) and provides a more comprehensive understanding of individuals' developmental changes over time.

Practice

Even though more people are getting the COVID-19 vaccine, pandemic precautions like handwashing, wearing masks, social contact limitations, and physical distancing are still essential to slow the spread of the virus, especially with the emergence of new variants. While vaccines are a crucial tool to beat the virus, they cannot be used alone at this time. Because a favorable evaluation of health behaviors leads to their application within the population (e.g. Côté et al., 2023; Courdi et al., 2023; Wollast et al., 2021), governments, policymakers, health institutions, and experts should establish communication plans that encourage people to develop a favorable attitude toward such health behaviors. These communication strategies should encourage COVID-19 preventive behaviors as a function of specific sociodemographic groups (e.g. young men, people against vaccines), while taking into account the difficulty for people to apply some of these behaviors (e.g. inhibition of natural tendencies to interact with others) as well as the negative psychological impacts of such specific measures.

Although several studies have demonstrated the negative consequences of social distancing practices during COVID-19 (e.g. Pfefferbaum & North, 2020; Rajkumar, 2020), some studies also revealed the positive impact of these practices when people possess the appropriate coping skills to deal with such major changes (Abdelrahman et al., 2022). For instance, Wollast, Lacourse, Mageau, et al. (2023) evidenced promising associations between self-compassion and well-being during the COVID-19 crisis. Specifically, they found that for individuals high in self-compassion, greater mental health was observed, suggesting that interventions focusing on low self-compassionate individuals may increase their resiliency in times of crises (see also Wollast et al., 2019).

Conclusion

The current pandemic has affected everyone and changed the ways in which each of us relates to and navigates the world. Even though the arrival of COVID-19 vaccines marked a turning point in the pandemic, health behaviors are still necessary to prevent the spread of the virus. Because social and physical distancing may lead to detrimental psychological consequences, new policies and communication strategies should encourage the adoption of health behaviors in light of the mental health burden that such measures may generate.

Note

1. The education data was not available for 29.3% of participants.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Fondation Louvain, Fonds De La Recherche Scientifique – FNRS.

Data availability statement

The online version of this article contains supplementary material, which is available at https://osf.io/cq2m6/.

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