Handwashing Adherence and the Trajectory of COVID-19 Pandemic: Findings from 14 Countries

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Abstract

Background: The COVID-19 pandemic has affected people's engagement in health behaviors, especially those that protect individuals from SARS-CoV-2 transmission, such as handwashing/sanitizing. Associations between the pandemic's trajectory and engagement in the protective behavior of handwashing are unclear. This study investigated whether adherence to the World Health Organization's (WHO) handwashing guidelines is associated with (i) total cases of COVID-19 morbidity/mortality accumulated since the onset of the pandemic, (ii) recent cases (country-level COVID-19 morbidity/mortality in the 14 days prior to data collection), (iii) increases/acceleration in recent cases (country-level COVID-19 morbidity/mortality in the previous 14 days minus cases recorded 14-28 days earlier), and (iv) stringency of the national containment-and-health policies (in the 7 days prior to data collection).

Methods: The observational study (#NCT04367337) enrolled 6,064 adults residing in Australia, Canada, China, France, Gambia, Germany, Israel, Italy, Malaysia, Poland, Portugal, Romania, Singapore, and Switzerland. Data on cross-situational handwashing adherence were collected via an online survey (March–July 2020). Individual data were matched with the WHO daily reports of COVID-19 and indices of containment-and-health policies. Country-level human development index and sociodemographic variables were controlled.

Results: Multilevel regression models indicated that as the total cases of COVID-19 morbidity and mortality grew higher, handwashing adherence decreased. As increases in recent cases of COVID-19 morbidity and mortality occurred, handwashing adherence increased. Higher levels of containment-and-health policy index were associated with lower handwashing.

Conclusions: Research investigating protective behaviors should account for indicators of fluctuations of COVID-19 morbidity/mortality, besides accounting for time since the beginning of the pandemic.

Trial Registration: ClinicalTrials.Gov, #NCT04367337, first registration date: 29/04/2020

Introduction

The person-to-person transmission of SARS-CoV-2 can be reduced by washing hands with soap and water or with an alcohol-based sanitizer as recommended by the World Health Organization (WHO) [1]. Improving hand hygiene practices may reduce COVID-19 rates as SARS-CoV-2 survives up to 9 hours on human skin [2]. Studies conducted at the beginning of the COVID-19 pandemic showed handwashing or sanitizing rates were as high as 97% in some population segments and circumstances (e.g., older people, washing or sanitizing hands for 20 seconds after returning home [3]) and as low as 53% in others (e.g., young adults, washing or sanitizing hands after coughing or sneezing [4]). The WHO [1] and Centers for Disease Control and Prevention (CDC) [5] handwashing guidelines specify 'how', 'how long', and 'when' to wash/sanitize hands. The recommended behavior includes washing all surfaces of hands (the 'how' rule) for 20 seconds (the 'how long' rule), as well as performing it regularly across situations such as before preparing food or eating and after using the toilet, blowing one's nose, coughing, sneezing, touching garbage, or visiting public spaces (the 'when' rule). [1]. Although measures of handwashing applied during the COVID-19 pandemic usually address 'how' and 'how long' rules, they refer to selected situations only (e.g., after coughing/sneezing or returning home [3, 4, 6]), or assess washing/sanitizing hands 'regularly' [7], without accounting for the situational context, addressed in the WHO [1] guidelines.

The COVID-19 pandemic is often described by reports of accumulation of the total cases of COVID-19 morbidity and mortality occurring since the beginning of the pandemic [8] or by daily rates of morbidity and mortality (e.g., reported as the average for the previous 7 or 14 days; [9]). The trajectory is also defined by periods of increases/acceleration of cases, that may be characterized as pre-exponential and exponential growth of daily cases (e.g., within previous 14 days, compared to previous 15-28 days) [10]. The periods of increases may be followed by a decline (or a decay) of cases (defined as a decline of daily cases, e.g., within previous 14 days, compared to previous 15-28 days), or a deceleration of growth and achieving a relatively stable level in daily cases [10]. For example, in Germany, the first period of increase in cases occurred between mid-March and late March 2020, followed by a decline of weekly-reported cases until late April 2020, that was followed by a decelerated, stable level of new cases lasting approximately until the end of September 2020 [9].

Research investigating the determinants of health protective behaviors such as face mask wearing and handwashing/sanitizing during the COVID-19 pandemic has typically treated the COVID-19 pandemic as a binary variable, comparing behaviors 'during' the pandemic to those before the pandemic [11,12]. The rates of protective behaviors such as handwashing during the pandemic were usually explained by individual-level psychosocial or demographic variables [13,14], without accounting for the changes in pandemic trajectory or policies issued in response to the exponential growth of the new COVID-19 cases (the Oxford COVID-19 Government Response Tracker, [15]). More complex and sophisticated approaches to behavioral determinants compared changes in behavior (e.g., physical activity) over time and investigated if changes in behaviors coincide with the introduction of containment-and-health policies while accounting for the time elapsing since the beginning of the COVID-19 pandemic [12].

Individual-level predictors, highlighted in health behavior change models such as theory of planned behavior [13], may be treated as the key determinants of protective behaviour. In contrast, social-ecological models highlight the role of determinants that operate at the societal level [16,17,18]. The societal level predictors include factors that reflect social inequalities, environmental factors, and public policies that may promote or hinder certain behaviors, but also information about the behavior and illness that is widely available in the environment [16,17,18]. During the first wave of the pandemic, national and global rates of COVID-19 morbidity and mortality were publicized daily in news media and social media, and levels of COVID-19 morbidity and mortality were found to be strongly correlated with frequency of media coverage of the pandemic [19]. People were found to correctly estimate total COVID-19 morbidity in their country during the first wave of the pandemic [20].

Several behavior change intervention frameworks (i.e., choice architectures approach [17]) highlight the role of information-based cues that nudge individuals to alter their health behaviors. Specificity of information about the COVID-19 pandemic, displayed regularly in news and social media [19], refers to raising awareness of human mortality due to COVID-19. Terror management theory (TMT; [21,22]) proposes a direct link between mortality salience (or
awareness of information about mortality) and health behaviors: in the context of conscious thoughts of death, health behaviors oriented at the removal of health-related threats would occur. Thus, the initial exposure to information on daily (or total) cases of COVID-19 morbidity and mortality may result in an increase of behaviors targeting self-protection and risk reduction, such as washing or sanitizing hands.

According to TMT [22] health-protective behaviors are assumed to help individuals rid mortality-related thoughts from focal attention. After information about mortality becomes effectively removed from focal attention (e.g., by an initial increase of engaging in protective behaviors), rates of protective behaviors may start to decline and, instead, individuals may start to engage in behaviors that enhance self-esteem and provide a sense of meaning and value. In line with TMT, it may be expected that protective health behaviors fluctuate, depending on the presence of mortality-related information in focal attention [22]. Thus, after an initial rise at the beginning of the COVID-19 pandemic, handwashing rates may decline as total cases of COVID-19 morbidity and mortality accumulate over time (and respective information is removed from focal attention). On the other hand, increases in COVID-19 morbidity and mortality (and the exposure to related information) may result in increasing mortality salience and, consequently, a temporary increase of handwashing.

Since the onset of the pandemic, governmental responses including containment-and-health policies (e.g., school and workplace closures, travel bans, testing policies, contact tracing, face coverings) were introduced, withdrawn, and reintroduced, with their timing and the stringency level depending on changes in COVID-19 morbidity and mortality trajectories across countries [15]. An introduction of a containment policy in the form of school closures in the USA during the first wave of the pandemic was associated with changes in hand hygiene behavior in hospitals, with a significant increase in hand sanitizing observed in the 2 weeks before the introduction of the policy, followed by a 2-week peak of high-frequency hand sanitizing occurring directly after policy introduction, which was followed by a significant decline in hand sanitizing during subsequent 10 weeks when the policy was still operating [23]. The increase of handwashing observed before the introduction of a containment policy reported by Moore et al. [23] coincided with a sharp increase in cases of COVID-19 morbidity in the USA, with a decrease in handwashing adherence coinciding with a flattening of the daily-cases curve [9].

The present study investigated if adherence to handwashing guidelines (issued by the WHO [1]) would be associated with the following indicators of trajectory of the COVID-19 pandemic: (i) total cases of COVID-19 morbidity and mortality accumulating since the onset of the pandemic, (ii) recent cases (COVID-19 morbidity and mortality in the previous 14 days), (iii) an increase in cases (COVID-19 morbidity and mortality cases recorded in the 14-28 days prior to data collection subtracted from morbidity and mortality recorded in 14 days prior to data collection), and (iv) national-level containment-and-health policies aimed at scaling down the COVID-19 pandemic (assessed in 7 days prior to data collection). The study aimed to explain handwashing adherence in the general population during the first wave of the COVID-19 pandemic (March-July 2020) in 14 countries within Europe, Asia, North America, Africa, and Australia. The effects of hypothesized predictors were estimated while controlling for social inequalities between countries (i.e., Human Development Index) and individual-level variables (e.g., sociodemographic variables, exposure to handwashing guidelines, being a healthcare professional).

Methods

Procedure

This preregistered observational study (see Clinical Trials.Gov, #NCT04367337, first registration date: 29/04/2020) was conducted in 14 countries: Australia, Canada, China, France, Gambia, Germany, Israel, Italy, Malaysia, Poland, Portugal, Romania, Singapore, and Switzerland. These countries had different COVID-19 morbidity and mortality trajectories within the study period and differed in cultural context that may affect handwashing. Data collection was initiated on March 24th, after obtaining ethics clearance (following the institutional regulations in each study country) and preparing 8 country/language versions of all study materials. Data collection continued until July 22nd 2020.

Individual-level data were collected via web-based survey using Qualtrics platform. The questionnaire took approximately 15 minutes to complete. Snowball sampling was adopted as the main recruitment strategy, with social networks and university websites used to advertise the study. Links to the survey were posted online, together with information about the study aims and design. The only inclusion criterion was being ≥ 18 years old. Informed consent was obtained, and data were anonymized. There was no compensation for participation. Before starting the questionnaire, participants were provided with information regarding the WHO handwashing guidelines [1]. The information provided to participants indicated that the guidelines refer to ‘washing hands regularly, for at least 20 seconds using water and soap or alcohol-based hand rub, scrubbing all the surfaces of hands, in the following situations: before, during and after preparing food, before eating, when caring for the sick, after using the toilet, after coughing or sneezing, after handling animals or animal waste, or when hands are visibly dirty.’ The Hebrew language version included an explanation that the questionnaire addresses handwashing for hygiene-related purposes and it does not deal with ceremonial or religiously motivated handwashing. Next, information related to sociodemographic variables, selected social-cognitive variables, and adherence to WHO handwashing guidelines across situations was collected via self-report.

Daily rates of COVID-19 morbidity and mortality from 20th January 2020 until 22nd July 2020 were obtained from the WHO Situation Reports [8] and indicators of containment-and-health policy responses to COVID-19 were obtained from the Oxford COVID-19 Government Response Tracker database [15]. COVID-19 and country-level containment-and-health policies data were matched with participants’ data using dates and countries of data collection.

Participants

Overall, 6,064 individuals provided data. The profile of the sample is provided in Table 1.

Table 1.

Sociodemographic and Key COVID-19-related Variables Across the Study Countries.
| Country/ variable | Australia | Canada | China | France | Gambia | Germany | Israel | Italy | Malaysia | Poland |
|------------------|-----------|--------|-------|--------|--------|---------|--------|-------|----------|--------|
| Total N          | 621       | 471    | 445   | 551    | 221    | 431     | 483    | 519   | 395      | 567    |
| Data collection dates in year 2020 | 29 Mar-03 Jul | 29 Mar-22 Jul | 28 Mar-24 Jun | 27 Mar-8 Jul | 08 Jun-19 Jul | 25 Mar-14 Jul | 4 Apr-19 May | 26 Mar-9 Jul | 4 Apr-09 Jul | 24 Mar-14 Jul |
| Gender, % men/ % women/ % other | 9.2/90.0/ 0.8 | 28.7/ 71.3/ 0.0 | 29.0/ 70.6/ 0.4 | 18.1/ 81.5/ 0.4 | 65.2/ 34.8/ 0.0 | 26.0/ 73.1/ 0.9 | 23.2/ 76.8/ 0.0 | 27.4/ 71.9/ 0.8 | 35.7/ 63.5/ 0.8 | 24.5/ 75.0/ 0.5 |
| Age, M, SD (min-max) | 42.51 (18-86) | 34.26 (18-80) | 23.02 (18-47) | 35.06 (18-80) | 31.11 (18-79) | 36.87 (18-79) | 49.04 (18-87) | 34.15 (18-88) | 38.87 (18-87) | 32.85 (18-88) |
| Education: % primary / % high school, vocational / % ≥ 3y. of higher education / % ≥4y of higher education | 0.6/ 13.06 | 23.2/ 60.6 | 8.5/ 42.2 | 21.6/ 46.2 | 14.5/ 54.8 | 19.0/ 58.8 | 6.7/ 41.8 | 24.4/ 23.7 | 8.7/ 62.2 | 5.8/ 7.6 |
| Perceived economic status: % below average/ % average/ % above average | 11.6/ 8.5/ 8.2 | 57.7/ 65.6/ 71.3 | 74.9/ 73.5/ 0.5 | 14.5/ 54.8 | 19.0/ 58.8 | 6.7/ 41.8 | 24.4/ 23.7 | 8.7/ 62.2 | 5.8/ 7.6 |
| Marital status: % married or living with a partner/ % other | 67.5/ 32.5 | 49.5/ 50.5 | 19.1/ 80.9 | 55.5/ 44.5 | 48.4/ 51.6 | 45.7/ 54.3 | 72.0/ 28.0 | 35.3/ 64.7 | 56.2/ 43.8 | 71.3/ 28.7 |
| Exposure to information regarding handwashing: % tv/mass media/ % social media/ % work/school/ % healthcare institutions/ mean % seen no information | 87.0/ 84.7/ 71.3 | 83.4/ 80.9/ 74.9 | 84.7/ 82.7/ 73.5 | 74.5/ 52.7 | 90.9/ 77.5 | 78.0/ 70.2 | 75.2/ 67.5 | 89.4/ 75.4 | 77.3/ 65.7 | 80.3/ 75.4 |
| Profession: healthcare services (%) | 10.6 | 10.8 | 6.5 | 24.5 | 28.1 | 7.7 | 9.9 | 9.4 | 20.8 | 16.6 |
| Being quarantined/isolated due to COVID-19: % no/ % yes | 84.7/ 15.3 | 80.5/ 19.5 | 90.3/ 9.7 | 58.4/ 41.6 | 93.7/6.3 | 92.3/ 7.7 | 88.4/ 11.6 | 53.0/ 47.0 | 68.6/ 31.4 | 96.5/ 3.5 |
| Deterioration of socio-economic situation during the COVID-19 pandemic: % Definitely yes/ % yes/ % no/ % Definitely not | 8.9/ 7.6/ 6.2/ 90.9 | 18.5/ 18.0/ 10.6/ 69.9 | 18.6/ 18.0/ 10.6/ 69.9 | 9.1/ 11.4/ 49.2/ 30.3 | 12.2/ 16.3/ 57.5/ 14.0 | 6.5/ 11.8/ 20.6/ 61.0 | 7.7/ 20.9/ 48.7/ 22.8 | 3.3/ 15.4/ 69.4/ 11.9 | 5.3/ 18.2/ 60.3/ 8.0 | 1.9/ 9.3/ 80.2/ 8.3 |
| Handwashing adherence (mean item scores): M, SD | 3.24, 0.58 | 3.21, 0.49 | 1.39, 0.54 | 3.25, 0.55 | 3.30, 0.59 | 3.32, 0.50 | 3.12, 0.53 | 3.30, 0.44 | 3.32, 0.50 | 3.28, 0.55 |
| New COVID-19 cases*: M, SD | 27.10, 50.70 | 794.86, 275.49 | 62.17, 42.55 | 1279.35, 591.60 | 0.95, 0.51 | 3323.53, 1569.82 | 429.05, 123.61 | 3741.24, 1828.60 | 116.30, 47.33 | 163.96, 121.93 |
| New COVID-19 deaths*: M, SD | 1.37, 0.41 | 83.77, 36.82 | 11.14, 25.28 | 336.09, 161.53 | 0.05, 0.03 | 126.24, 66.47 | 4.82, 1.35 | 513.74, 218.13 | 2.33, 1.28 | 6.67, 8.01 |
| Total COVID-19 cases: M, SD | 6850.06, 293.01 | 83057.20, 28650.47 | 83589.90, 9196.70 | 132870.33, 13552.14 | 49.70, 15.95 | 123642.79, 40579.64 | 10843.05, 2852.01 | 142495.30, 58024.40 | 5074.28, 1444.06 | 6240.98, 8252.17 |
| Total COVID-19 deaths: M, SD | 93.68, 12.12 | 6609.06, 2658.32 | 3918.7, 656.39 | 25333.88, 3520.88 | 2.18, 0.86 | 3844.95, 2725.23 | 106.64, 67.13 | 18247.43, 9544.74 | 82.90, 22.38 | 263.42, 395.08 |
| 2-week change in COVID-19 cases*: M, SD | -20.84, 53.68 | -196.56, 354.43 | 7.40, 27.99 | -1147.32, 687.47 | 0.23, 0.37 | 844.20, 2710.99 | 214.25, 219.09 | 15753.39, 2101.96 | 6.46, 68.93 | 53.90, 63.58 |
| 2-week change in COVID-19 deaths*: M, SD | -0.36, 0.55 | -11.04, 24.03 | -2.85, 33.96 | -295.56, 132.06 | 0.01, 0.04 | 46.49, 61.48 | 2.95, 2.57 | 296.73, 296.20 | 0.68, 2.30 | 1.17, 3.96 |
| Containment-and-health policy index*: M, SD | 70.10, 1.38 | 71.78, 1.11 | 74.52, 7.92 | 78.98, 1.53 | 72.06, 2.64 | 70.40, 2.49 | 85.51, 3.97 | 82.86, 11.59 | 74.80, 3.64 | 57.58, 9.90 |

Note. M = Mean; SD = Standard deviation; Handwashing adherence = cross-situational adherence to the WHO handwashing guidelines; Profession: healthcare services.
COVID-19 pandemic; Means and SD for COVID-19 morbidity and mortality indices and containment-and-health policy indices were calculated for days matching COVID-19 morbidity/mortality cases accumulated since the beginning of the pandemic (per country and per date); New COVID-19 cases/deaths = the number change in COVID-19 cases = a difference in the mean of new cases of COVID-19 in the 14 days prior to data collection, compared to the mean of country new collection; higher scores indicate more new cases in 14 days previous to data collection compared to 15-28 days before data collection; 2-week change in CO in the same manner as change in COVID-19 cases, Containment-and-health index = COVID-19-related containment-and-health stringency policies (country-and-week-specific data).

Materials

Assessment of Individual-Level Variables

Cross-Situational Handwashing Adherence Index (Based on WHO Guidelines). A 12-item measure assessing handwashing was developed for this study. This measure was adapted from previous measures [3,4,6] to capture adherence across situations [1]. The stem ‘During the previous week, I’ve usually washed my hands (for at least 20 seconds, all surfaces of the hands)’ was followed by the 8 situational contexts specified in the WHO guidelines: ‘Before, during, and after preparing food’, ‘Before eating food’, ‘Before and after caring for someone at home who is sick with vomiting or diarrhea’, ‘After using the toilet’, ‘After blowing my nose, coughing, or sneezing’, ‘After touching garbage’, ‘After visiting public spaces’, ‘When my hands were visibly dirty’. Responses were provided on a scale ranging from 1 (strongly disagree) to 4 (strongly agree). Participants were asked if they encountered the following situations during the previous week: caring for someone sick, taking care of an infant, caring for an animal, or treating a wound or a cut. If a respondent indicated that they did not encounter one or more of these situations in the previous week (e.g., they did not care for an infant), the respective item was removed from the mean item score value for the participant. The mean item scores for handwashing adherence are reported in Table 1.

Sociodemographic Variables. Data referring to country of residence, age, gender, marital status, education, and perceived economic status were collected. Perceived economic status was measured with one item, ‘Comparing to the average situation of a family in your country, what is the economic situation of your family?’, with responses ranging from 1 (much above the average) to 5 (much below the average). Participants indicated their education level with responses representing the following 4 levels: primary school, vocational education or completed high school, ≤ 3 years of higher education, ≥ 4 years of higher education.

Participants’ COVID-19 Pandemic-Related Situation. Data were collected to capture individuals’ COVID-19-related situation. These data included: (i) the deterioration of socio-economic situation during the COVID-19 pandemic (‘I’ve lost my job/source of income or the economic situation of my family has significantly worsened due to the COVID-19 pandemic’; responses ranging from 1 = definitely yes to 4 = definitely no); (ii) being employed as health care professional during the COVID-19 pandemic (yes-no response format, with 1 = healthcare-related profession, 0 = other profession); (iii) being quarantined/isolated due to COVID-19 (Are you in SARS-CoV-2 quarantine now?; responses options of 1 = yes or 0 = no); and (iv) exposure to information regarding handwashing with 4 items featuring the stem ‘During the previous week, I’ve usually washed my hands (for at least 20 seconds, all surfaces of the hands)’ was followed by the 8 situational contexts specified in the WHO guidelines: ‘Before, during, and after preparing food’, ‘Before eating food’, ‘Before and after caring for someone at home who is sick with vomiting or diarrhea’, ‘After using the toilet’, ‘After blowing my nose, coughing, or sneezing’, ‘After touching garbage’, ‘After visiting public spaces’, ‘When my hands were visibly dirty’. Responses were provided on a scale ranging from 1 (strongly disagree) to 4 (strongly agree). Participants were asked if they encountered the following situations during the previous week: caring for someone sick, taking care of an infant, caring for an animal, or treating a wound or a cut. If a respondent indicated that they did not encounter one or more of these situations in the previous week (e.g., they did not care for an infant), the respective item was removed from the mean item score value for the participant. The mean item scores for handwashing adherence are reported in Table 1.

Assessment of Country-Level Variables

Human Development Index. Values of 2019 country-level indicators of Human Development Index (HDI), capturing overall development, health, and educational situations were obtained for the 14 countries participating in this study [24].

COVID-19-Related Containment-and-Health Stringency Policies (Country-and Week-Specific Data). Containment-and-health policy index data were extracted from the Oxford COVID-19 Government Response Tracker database [15]. This index combines ‘lockdown’ restrictions and closures with measures such as testing policy and contact tracing, short term investment in healthcare, as well as investments in vaccination. In contrast to other indices (e.g., overall government response), the containment-and-health index refers directly to health-related policies and excludes economic measures such as income support and debt relief. It is calculated for each country for each week since the beginning of the COVID-19 pandemic and its values range from 0 to 100, with higher levels representing more stringent policies. Individual-level data was matched with the containment-and-health index value valid for the week when data of each respective participant was collected.

COVID-19 Morbidity and Mortality (Country-and-Day-Specific Data). COVID-19 mortality and morbidity values were calculated for each person based on the date of their participation in the study. In particular, COVID-19 mortality and morbidity data for the 14 study countries for each day of data collection were extracted from the daily Coronavirus Disease Situation Reports [8]. Daily reports from 20th January to 22nd July 2020 were used to identify: (i) the number of new COVID-19 cases and deaths per country per day; (ii) the number of total COVID-19 cases and deaths from the beginning of pandemic per country per date; (iii) a 2-week change in COVID-19 cases, represented by a difference in the mean of new cases of COVID-19 in the 14 days prior to data collection compared to the mean of a country’s new cases of COVID-19 in the 15-28 days before the date of data collection (higher scores indicate more new cases in prior 2 weeks compared to 15-28 days before data collection); (iv) a 2-week change in COVID-19 deaths, calculated in the same manner as change in COVID-19 cases. Individual-level data was matched with the morbidity and mortality indices values for the day when data of each respective participant was collected.

Data Analysis

Of the 6,397 potential respondents who provided their consent, n = 333 (5.2%) provided sociodemographic information only and withdrew from providing further data. These cases were excluded from any analyses. The excluded subsample did not differ (all ps > .05) from the final sample (N = 6,064) in terms of age, gender, education, and economic status. Data for the basic sociodemographic variables (age, gender) and handwashing adherence were missing
completely at random, Little’s MCAR $\chi^2 = 6.26$ (df = 3), $p = .098$. Missing data analysis accounting for all individual-level variables were not missing at random, Little’s MCAR $\chi^2 = 165.53$ (df = 21), $p < .001$. Missing self-reported data in the final sample were accounted for by using the full information maximum likelihood procedure.

Preliminary analyses (correlations, descriptives) were conducted with IBM SPSS 26. Individual-level predictors that were significantly associated with the handwashing adherence index were included in the main analyses (multilevel regression). Separate models were fit for each of the 6 COVID-19 morbidity and mortality indices, due to multicollinearity issues.

The multilevel regression analyses were conducted using the lme4 R package [25], R version 4.0.3 [26] and restricted maximum likelihood estimation procedures. Each of the 6 models accounted for 8 predictors. Owing to the complexity of the model and limitations of the estimation method, there was no convergence when the country-level variables (COVID-19 morbidity, mortality and policies) were modeled as random effect predictors. Thus, predictor variables were assumed to represent fixed effects, with the final model assuming random effects only for the intercept for each country. Non-nominal data were standardized in each model. Outliers were defined with Cook’s distance as values of $M > 3.0$. Outliers were identified for each model and excluded from respective analyses. To explore potential nonlinear effects, artificial neural networks with 4 hidden layers and softmax activation function were calculated. These showed poor model-data fit and are thus not reported here.

**Results**

**Preliminary Analyses**

Table 1 presents mean item responses for handwashing adherence and Figure 1 presents mean values for handwashing across the 8 situations indicated by the WHO [1]. Bivariate correlation analyses conducted for the total sample ($N =$ 6,064) indicated that higher handwashing adherence was associated with the following predictors: lower levels of COVID-19 morbidity since the beginning of the pandemic, an increase in COVID-19 cases in the 14 days prior to data collection (compared to 15-28 days earlier), and a lower level of containment-and-health policy introduced in the week prior to data collection (all $p$s < .013; see Additional File 1). Furthermore, higher handwashing adherence was associated with the following individual-level variables: female gender, older age, being married/living with a partner, healthcare profession, and being exposed to information on handwashing (all $p$s < .042; see Additional File). Handwashing adherence was unrelated to education, perceived economic status, worsening of economic status during the pandemic, or being in quarantine (all $p$s > .081; see Additional File). These variables were therefore excluded from the main analyses.

**Main Findings: Predicting Handwashing Adherence with COVID-19 Morbidity and Mortality and Containment-and-health Policies**

Table 2 displays the findings obtained in main analyses, conducted for the 6 COVID-19 morbidity and mortality indices separately. These analyses accounted for the random intercept for countries and fixed effects of the country-level predictor variables. The predictors explained between 14.9% and 15.2% of the variance of handwashing adherence.

The analyses conducted for the 6 COVID-19 morbidity and mortality indices were tested separately and yielded a complex pattern of associations between the trajectory of the pandemic and handwashing adherence (Table 2). As the number of total cases of COVID-19 morbidity and mortality (counted since the beginning of the pandemic in a respective country) grew higher, handwashing adherence decreased. However, when increases in recent cases of COVID-19 morbidity and mortality occurred (cases recorded in the 14 days prior to data collection compared to the cases recorded 15-28 days earlier), handwashing adherence increased. Higher stringency in policy responses, reflected by higher levels of containment-and-health policy index (obtained for the respective country in the week prior to data collection) were associated with lower adherence to handwashing.

Across analysed models, the country-level human development index was unrelated to handwashing adherence. Across models, higher handwashing adherence was associated with individual-level variables: being older, being female, being married, performing a healthcare job during the pandemic, and being more frequently exposed to handwashing guidelines.

Table 2.

*Six Models for Six Indicators of Trajectory of COVID-19 Pandemic Predicting Cross-Situational Handwashing Adherence*
### Discussion

This study is among the first showing that the trajectory of the COVID-19 pandemic, defined as accumulation of cases of COVID-19 and increases in recent cases (previous 14 days compared to 15-28 days before the day of data collection), differentiates levels adherence to handwashing. Adherence to handwashing may decline over time, as the total number of pandemic-related morbidity and mortality cases accumulate. However, higher levels of handwashing may occur when there is an increase in recently reported cases of or deaths from COVID-19. Although the observed effects were small, small effects are expected with large, heterogeneous samples.
The approach stressing the role of the pandemic trajectory is in contrast to the dominant approaches to explaining health behaviors and their changes during the COVID-19 pandemic. These approaches investigate changes in health behavior (during the pandemic versus before the onset of the pandemic; e.g., [27]) or just investigate health behaviors ‘during the pandemic’ [3,4,6,13]. These approaches do not account for the COVID-19 pandemic trajectory. The present study represents a novel contribution to the literature by demonstrating that COVID-19 morbidity and mortality trajectories are important determinants of engagement in the health-protective behavior of handwashing. Instead of observing a ‘pandemic fatigue’ [28], defined as a decline in health-protective behaviors over time, our study shows a potential ‘falling and peaking’ pattern, representing effects of accumulation of total cases of COVID-19 combined with increases in recent cases of COVID-19 morbidity and mortality. Consequently, we argue that research on behavior change during the pandemic should consider total cases and increases in recent cases of COVID-19 morbidity and mortality.

The findings are in line with the general assumptions of social-ecological models of health behaviors, highlighting the role of behavioral determinants that operate at the societal level [16-18]. They are also in line with TMT [21,22] and suggest that frequency of protective health behaviors may decline over time, as mortality information is effectively removed by individuals from their focal attention. Thus, even if COVID-19 morbidity and mortality cases accumulate and individuals are still being regularly exposed to respective mortality information, lower instead of elevated handwashing levels may be observed. However, increases in recent cases may bring COVID-19 mortality back to the focal attention, resulting in spikes in handwashing behaviors. This pattern of associations is consistent with the increase, plateau, and reduction of handwashing observed in a study by Moore et al. [23], in which the trajectory of hand sanitizing adherence reflected changes in COVID-19 morbidity in the first wave of the pandemic.

The present study showed that higher values of containment-and-health policy index were related to lower cross-situational adherence to handwashing guidelines [1]. It is possible that the total number of key handwashing occasions decreased as there were fewer situations in which participants found themselves that demanded handwashing (e.g., school and shop closures). However, the assessment applied in this study did not focus on the number of handwashing acts over a day, but the level of adherence in specific situations, if they were encountered. As such, the handwashing adherence should not be affected by fewer ‘going out’ opportunities. Previous research also showed a decline of hand sanitizing over a 10-week period when a containment policy was in operation [23]. These findings may seem in contrast to an assumption that the policies should promote awareness and protective behaviors. During the first wave of the pandemic an increase of containment-and-health policy index usually followed a sharp increase in COVID-19 morbidity and mortality [15] and more stringent policies were kept in operation after a decline or deceleration of growth of COVID-19 [15, 23]. Hence, the effect of the level of strictness of health and containment may be hard to distinguish from the effects of COVID-19 morbidity and mortality trajectory. Furthermore, a reduction of health protective behavior after an increase in stringency of containment-and-health policies may be explained by individuals’ beliefs that protective policies would reduce the likelihood of being exposed to SARS-CoV-2, hence they do not need to adhere to handwashing routines (for similar mechanisms see the compensatory health beliefs model [29]).

The ‘falling and peaking’ pattern in the levels of handwashing adherence, coinciding with changes in COVID-19 trajectory, has implications for health behavior change interventions and policies. Health promotion efforts may be particularly needed during deceleration or stable levels of COVID-19 morbidity and mortality to enhance conscious and non-conscious processes fostering habits of washing hands after coughing or sneezing, before preparing food, or after caring for someone who is ill.

While this study has several strengths, such as the large sample providing an opportunity to detect small effects and data collection in 14 countries with varying COVID-19 trajectories, there are several limitations. Although COVID-19 and policy data used in this study were prospective, individual-level data were cross-sectional, which did not allow to capture within-individual changes over time. The changes of the pandemic trajectory were captured at the between-person level only. Fitting models accounting for random effects across 14 countries would allow testing if the observed patterns differ across countries, but the relative complexity of the models did not allow for calculating random effect predictions of COVID-19 indicators. The underlying mechanisms through which COVID-19 morbidity and mortality trajectories may affect protective behavior were not investigated. Such mechanisms may include individuals’ conscious and unconscious processes [17], including changes in risk perception [30] or other social cognitive variables [13]. Future research should investigate if pandemic trajectory variables explain behavior change over and above a set of theory-based predictors of handwashing or can be fully explained by these psychological mechanisms.

**Conclusions**

This study provides an insight into the associations between the indicators of the trajectory of the COVID-19 pandemic and a protective health behavior, adherence to handwashing guidelines in samples of the general population recruited in 14 countries across 5 continents. The study investigated adherence across 8 situations, such as before preparing food or eating, after using the toilet, blowing one’s nose, coughing, sneezing, touching garbage, or visiting public spaces [1]. Handwashing adherence declined as total cases of COVID-19 morbidity and mortality accumulated, but it increased during periods of acceleration of the pandemic (e.g., pre-exponential and exponential growth of COVID-19 cases). Research should account for COVID-19-related total cases and recent increases in cases when collecting data relating to behaviors preventing SARS-CoV-2 transmission, in addition to focusing on health behavior and its change ‘during the pandemic’.

**Abbreviations**

COVID-19
Coronavirus disease 2019
World Health Organization
WHO
Centers for Disease Control and Prevention
Declarations

Ethics approval and consent to participate: The authors declare that they have no conflicts of interest with regard to this study. This study was approved by the Research Ethics Committee of the SWPS University of Social Sciences and Humanities (Faculty of Psychology in Wroclaw). All study procedures were carried out in accordance with the 1964 Helsinki declaration and its later amendments. Written informed consents were obtained from all participants.

Consent for publication: Not Applicable.

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests: The authors declare that they have no competing interests.

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Authors’ contributions: AL, RS and ZS made substantial contributions to the conceptions, AL, RS, ZS, NK, JK, MJ, CA, US, NV designed the work, all of the authors acquired the data, AL, KS, ZS and MS analyzed and interpreted the data, AL, ZS, KS and MS have drafted the work, all of the authors substantively revised it. Each author has approved the submitted version. Each author have agreed both to be personally accountable for the author's own contributions and to ensure that questions related to the accuracy or integrity of any part of the work, even ones in which the author was not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature.

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Figures
Figure 1

Situational Handwashing Adherence Following WHO (2020) Guidelines Across the Study Countries Figure Note. Participants were asked to indicate if during the previous week they have usually washed their hands (for at least 20 seconds, all surfaces of the hands) in the respective situation (with responses ranging from 1=strongly disagree to 4= strongly agree). Participants who indicated that they did not care for someone at home who is sick were excluded when calculating mean item response calculated for the respective situation.