Improving infection control behavior patterns in the home during the COVID-19 pandemic: an observational study of the web-based behavioral intervention ‘Germ Defence’

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Abstract

Background: To control the COVID-19 pandemic, people should adopt protective behaviours at home (self-isolation, social distancing, putting shopping/packages aside, wearing face-covering, cleaning and disinfecting, handwashing). There is currently limited support to help individuals conduct these behaviours.

Objective: We aimed to report current household infection control behaviours in the UK, and examine how they might be improved.

Methods: This was a pragmatic, cross-sectional observational study of anonymous participant data from Germ Defence (https://germdefence.org/), a freely available website providing behavioural advice for infection control within households. 28,285 users sought advice from four website pathways based on household status (advice to protect themselves generally, to protect others if the user was showing symptoms, to protect themselves if household members were showing symptoms, and to protect a household member who is at high risk). Users reported current infection control behaviours within the home, and intentions to change these behaviours.

Results: Current behaviours varied across all infection control measures but were between ‘sometimes’ and ‘quite often’, except handwashing (‘very often’). Behaviours were similar regardless of the website pathway used. After using Germ Defence, users recorded intentions to improve infection control behaviour across all website pathways and for all behaviours.

Conclusions: Self-reported infection control behaviours other than handwashing are lower than is optimal for infection prevention, although handwashing is much higher. Advice using behaviour change techniques in Germ Defence led to intentions to improve these behaviours. Promoting Germ Defence within national and local public health/primary care guidance could reduce COVID-19 transmission.

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Abstract

Background: To control the COVID-19 pandemic, people should adopt protective behaviors at home (self-isolation, social distancing, putting shopping/packages aside, wearing face-covering, cleaning and disinfecting, handwashing). There is currently limited support to help individuals conduct these behaviors.

Objectives: We aimed to report current household infection control behaviors in the UK, and examine how they might be improved.

Methods: This was a pragmatic, cross-sectional observational study of anonymous participant data from Germ Defence (https://germdefence.org/) between May 6th and May 24th 2020. Germ Defence is an open access, fully automated, website providing behavioral advice for infection control within households.

28,285 users sought advice from four website pathways based on household status (advice to protect themselves generally, to protect others if the user was showing symptoms, to protect themselves if household members were showing symptoms, and to protect a household member who is at high risk). Users reported current infection control behaviors within the home, and intentions to change these behaviors.

Results: Current behaviors varied across all infection control measures but were between 'sometimes' (face covering M 1.61, SD 1.19, socially distance M 2.40, SD 1.22, isolating M 2.78, SD 1.29, putting packages/shopping aside M 2.75, SD 1.55) and 'quite often' (cleaning/ disinfecting M 3.17, SD 1.18), except handwashing ('very often' M 4.00, SD 1.03). Behaviors were similar regardless of the website pathway used. After using Germ Defence, users recorded intentions to improve infection control behavior across all website pathways and for all behaviors (overall average infection control score MD 0.30, CI[0.29, 0.31]).

Conclusions: Self-reported infection control behaviors other than handwashing are lower than is optimal for infection prevention, although handwashing is much higher. Advice using behavior change techniques in Germ Defence led to intentions to improve these behaviors. Promoting Germ Defence within national and local public health/primary care guidance could reduce COVID-19 transmission.

Introduction

The impacts of COVID-19 must primarily be tackled through changes in behavior undertaken by individuals and societies, until a vaccine becomes available. In many countries (including the UK), people with COVID-19 infection are instructed to remain at home, together with co-habiting family or other household members, to prevent transmission between households. This increases the risk of within-household virus transmission. For example, in several environments where inter-household movement is well controlled (such as Taiwan, Ningbo and Shenzen [1-3]) the virus continues to proliferate within close contacts.

To interrupt these transmission pathways, individuals must adopt 'personal protective behaviors' [4]. Such target behaviors include handwashing, disinfection of surfaces, thorough cleaning and waste disposal, social distancing within the home (where possible) and wearing situationally-appropriate personal protective equipment. A recent cohort study in Beijing, China demonstrated that performing these behaviors could dramatically reduce the likelihood of household transmission, but the highest risk of transmission was prior to symptom onset (typically before such behaviors are performed) [5]. Therefore, protective behaviors should be implemented before any household members develop symptoms. There is substantial individual variation in these behaviors, which are complex, environmentally and culturally dependent, and influenced by individual attitudes and beliefs [6]. Changing such complex behaviors effectively and rapidly within the context of COVID-19 requires an approach based on behavior change theory, evidence and extensive participatory input [7].

Specific guidance for the public on protective behaviors has been developed in many countries and is widely recommended by politicians, the media and public health/primary care networks [8]. However, few behavioral interventions have been used to support the public in these behaviors within their homes. A systematic review by our group has found evidence of only one digital intervention to date (Germ Defence, https://germdefence.org/ [9,10]) that demonstrably improved health outcomes in respiratory tract infections (RTIs) within households. Germ Defence is a mobile-friendly website that provides targeted, tailored advice about how and why users should use infection control behaviors, aiming to supplement public health guidance with evidence- and theory-based behavior change techniques [11], optimized using extensive user feedback. In a large randomized controlled trial of 20066 people (the PRIMIT trial) during the previous H1N1 (swine flu) pandemic [12], those randomized to use Germ Defence had reduced frequency and severity of RTIs

and reduced transmission to household members. Germ Defence is a freely available resource and the intellectual property is held by the University of Southampton.

Germ Defence was rapidly adapted for the COVID-19 pandemic by a team of medical, public health and behavior change experts, and public contributors. It was then disseminated through multiple pathways (primarily but not exclusively in the UK) including public health and primary care networks (for example, by texting the website link to patients via GP practices), national and local press, television coverage and social media.

In this study, we aimed to:

1. Examine current infection control behaviors in UK households.
2. Compare current infection control behaviours with intentions to change behaviour after using Germ Defence to control infection transmission

Methods

Design

This was a cross-sectional observational study of anonymous participant data from an active behavioral intervention. Consent was assumed from website usage and acknowledged in the website privacy policy.

Participants and Data

The data analyzed were collected from users of the Germ Defence website between May 6th and May 24th 2020. During this period usage was driven by media coverage, and users were encouraged to share the intervention on social media and by email. During this period 70,566 website hits were recorded, with 53,125 users completing the introductory content (first three pages) and 28,285 people completing the core module, which included measures of current and intended behavior. Website usage and engagement data was collected using Google Analytics embedded in the site (see Figure 1 for full consort usage diagram).

Data collection was kept to a minimum to reduce dropout. Behavioral measures were recorded through self-report questions within the website, for current and intended behavior (see Table 1).

Table 1: Online self-report measures recorded during Germ Defence intervention

Behavior	Self-report item
'Reducing Illness' infection control	
Social distancing	When you were/are with them, how often were you/do you plan to be more than 2 metres/6 feet away from the people you live with?
Cleaning/Disinfecting	How often did you/do you plan to clean things that might have viruses on them?
Putting shopping/packages aside	How often did you/do you plan to put something aside for at least 1 day that might have viruses on it?
Self-isolating	How often did you/do you plan to spend time in a room on your own?
Wearing face coverings	How often did you/do you plan to wear a face covering and glasses (and safely remove and clean them) when you are in the same room as other people?
'Handwashing' behavior	
Before snacking	How often did you/do you plan to wash your hands before I ate/eat with my fingers e.g. snack, fruit or sweets?
After coming home	How often did you/do you plan to wash your hands when I came/come into a house e.g. after work, shopping, travelling?
After coughing	How often did you/do you plan to wash your hands after blowing my nose or sneezing/coughing on my hands?
After coming into contact with possible carrier	How often did you/do you plan to wash your hands after I had been/being close to someone who may have a virus (within 6 feet)
After touching something	How often did you/do you plan to wash your hands after touching something that lots of other people have touched e.g. doors, money or handrails?
Website helpfulness (recorded on a scale of 1-10)	
Helpfulness score	How strongly do you agree or disagree that Germ Defence was helpful to you?

Note: Measures were all scored on a Likert scale with answers of 1 (Almost never), 2 (sometimes), 3 (quite often), 4 (very often) and 5 (almost always). Users could also answer 'Not Applicable' (for example, if they lived alone and therefore did not need to socially isolate within their household).

Intervention

Germ Defence content was developed using theoretical modelling and qualitative research [13], in line with the person-based approach [14], drawing principally on the theory of

planned behavior [15], Leventhal's common-sense model of illness [16] and protection motivation theory [17]. Intervention content, design and structure were optimized iteratively using in-depth qualitative think-aloud interviews with public contributors (JB,CR) and members of the general public in order to ensure the intervention was accessible, credible and motivating for as many people as possible [14].

Based on process evaluations of the original randomized controlled trial [12] and a previous public dissemination [18], Germ Defence has been updated and streamlined for use during the COVID-19 outbreak, including broadening the infection control behaviors that were recommended. The intervention is a single session, designed to be easily accessible with no sign-up or password required. Full details of intervention structure and development are reported elsewhere [3,15,17,18] and archived copies available at http://archive.germdefence.org/ (see Germ Defence v3). Intervention content was "frozen" during the reported data collection period. A structured outline of content is available in Table 2.

Statistical analysis

We included data from all users who accessed the website during the study period.

For analysis, users were grouped according to the tailored website pathway they selected within the 'Reducing illness' component ('Protect myself generally' vs. 'Protect others if I am showing symptoms' vs 'Protect myself if a household member has symptoms' vs. 'Protect a household member at high risk'). Users could also view the Handwashing component which was relevant to all groups. If they did not view 'Reducing illness' they were not included in group comparisons, but handwashing responses were still recorded. Users could complete more than one type of tailored pathway but we only analyzed responses for the pathway that was selected first.

To understand current infection control behaviours (Aim 1), behavioral measures were analyzed individually, and also collapsed together to form an 'average infection control behavior' score. When users completed a plan more than once (eg. if they received website feedback that their initial plan could be further improved) the 'final' plan was used. If users did not think a behavior was relevant to them (for example, they lived alone so did not need to socially isolate, or could not socially isolate from young children) they could answer 'not applicable' – this was coded as missing data and not included in analysis. Linear regression compared between-group scores for behavior.

To compare current behaviours with intended behaviour after using Germ Defence (Aim 2),

linear regression models comparing between-group scores for intentions controlled for current behavior were used. Paired t-test comparisons examined the difference between current behavior and intended behavior within groups.

Table 2. A detailed outline of Germ Defence content and structure

Component	Component Details
Introductory content (3 pages)	Introductory pages seek to increase users' perceived risk by emphasizing the personal and social health consequences of contracting COVID-19. These are followed by messages to increase skills and confidence to reduce exposure to the virus.
Website pathway selection (2 pages)	To allow users to choose the advice they consider most personally relevant, the intervention is structured so that users initially select between two components of interest: Handwashing and Reducing Illness. The 'Reducing Illness' component is again tailored such that a user selects one of four streams of content (each lasting 11 pages) that is relevant to the user's situation: 1: to protect themselves generally; 2: to protect others if the user was showing symptoms; 3: to protect themselves if household member(s) showed symptoms; or 4: to protect a household member who is at high risk. The advice is tailored in this way to encourage users to adopt behaviors appropriate to the perceived level and pattern of risk in their household. For example, users in the 'protect themselves generally' would vary from very low to very high risk. It was not possible to provide specific tailored advice for every household combination of risks and resources (for example, based on the need and potential for household members to self-isolate within the home); therefore, Germ Defence aimed to educate users to adopt behaviors that were appropriate and feasible for their own circumstances.
Tailored infection control behavior advice (7 pages)	Clear and detailed advice is then provided for self-isolating, social distancing, disinfecting/cleaning, wearing face-coverings, and putting items aside that may have viruses on them such as shopping/packages. Advice is provided to the extent that users feel is appropriate for the perceived risk. These pages also contain ideas and information on how to structure the home and engage in behaviors safely. The handwashing component provides advice focused on handwashing that is relevant to all groups over 5 pages.
Goal setting advice (3 pages)	Both the Handwashing and Reducing Illness components contain goal-setting sections where users indicate their behavior over the past week, view a motivational message, and then plan their behavior for the future. Users who do not select any improvement are encouraged to review their plan. After completing either Handwashing or Reducing Illness components, users are asked how helpful they found the website.
Additional information	Users are then able to revisit the first two components, choose from two additional components with more detailed information about the

	same behaviors (eg, how to social distance with young children, how to stop touching your face), or view details about the website.

Note: The website, and all associated content, can be accessed for free [9].

Results

Usage of the Germ Defence website

We considered data from 53,125 users who completed at least the initial introductory website pages. Users accessed Germ Defence from 129 countries (a full consort diagram of usage is presented in Figure 1). 83.7% (n = 44,466) of users were from the UK (England 75.6% n = 40,164, Scotland 4.2% n = 2,204, Wales 2.8% n = 1,459, Northern Ireland 1.1% n = 566, other UK 0.1% n = 73). Mean usage lasted 8 minutes 28 seconds, and mean number of pages viewed was 19.9. 54.1% of recorded sessions (N = 28,740) lasted longer than one minute. 54.0% of users (n = 28,687) accessed Germ Defence using a mobile device, 31.0% with a tablet (n = 16,469) and 15.0% with a desktop or laptop computer (n = 7,968). 10.6% of users were ‘return users’ visiting for a second time (n = 5,631). Aggregated usage statistics for users outside the UK are provided in Appendix A. Detailed usage for each website component is presented in Figure 1. Overall mean helpfulness of the website was rated as 7.77 out of 10 (SD 2.31).

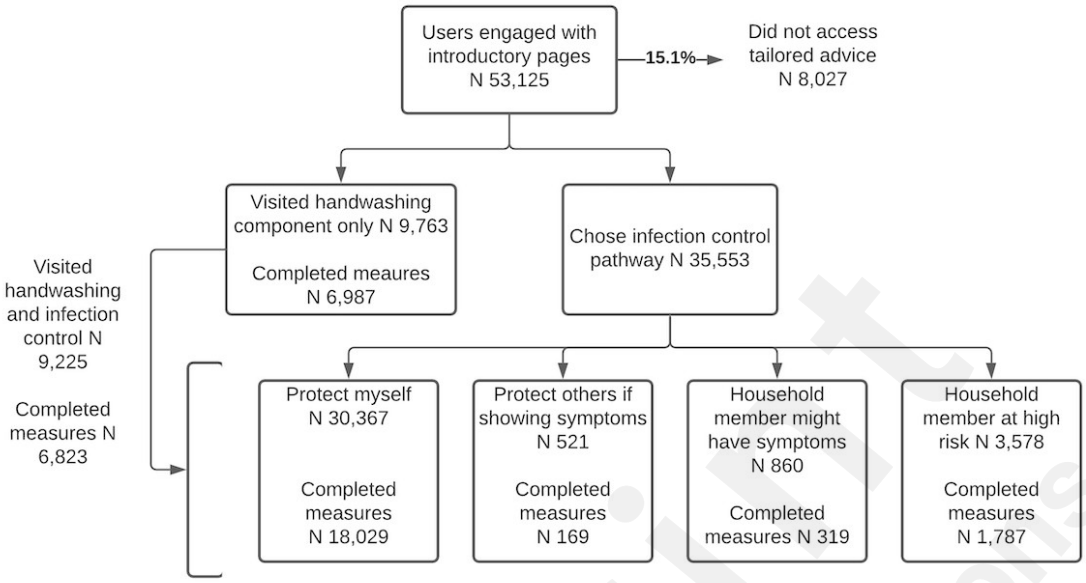

Figure 1: A consort diagram of Germ Defence website usage (and group categorization)

Infection control behaviors and intended behaviors in users of Germ Defence

All groups (protect themselves generally, protect others if the user was showing symptoms, protect themselves if household members were showing symptoms, and protect a household member who is high risk) reported using most current infection behaviors sometimes/quite often within the home. Overall, users reported they would wear a face covering almost never/sometimes (M 1.61, SD 1.19) and would socially distance sometimes/quite often (M 2.40, SD 1.22). Users reported socially isolating in their own room sometimes/quite often (M 2.78, SD 1.29) and putting packages/shopping aside sometimes/quite often (M 2.75, SD 1.55). Users reported cleaning/disinfecting quite often/very often (M 3.17, SD 1.18).

Frequency of the five infection control behaviors from the ‘Reducing Illness’ pathway within each group is reported in Table 3 (with handwashing reported separately below), as well as mean differences and confidence intervals of group comparisons (each group vs. ‘Protect themselves generally’ group). The frequency of behaviors did not vary appreciably between groups; numerically, the ‘Protect themselves generally’ group were least likely to socially distance (M 2.39, SD 1.22). People in the ‘Protect others if user showing symptoms’ group were least likely to clean/disinfect (M 2.95, SD 1.26) and put aside shopping/packages (M 2.39, SD 1.48) but most likely to wear a face covering (M 1.91, SD 1.36). People in ‘Protect themselves if household members showing symptoms’ were most likely to maintain social distance (M 2.57, SD 1.23), and users in ‘Protect household

members at high risk' were least likely to stay in their own room (M 2.64, SD 1.16) and least likely to wear a face covering (M 1.42, SD 0.99)

Table 3 shows some small differences in how often participants planned to perform behaviors in the future (corrected for levels of current behavior) between groups. Compared to people in the 'Protect themselves generally' group, people showing symptoms planned to clean/disinfect and put aside less frequently, but planned to self-isolate more frequently. People in the 'Protect themselves from household member with symptoms' group planned to socially distance and self-isolate more frequently than those in the 'Protect themselves generally' group. People looking to protect a high-risk household member planned to conduct all of the behaviors slightly more frequently than the 'Protect themselves generally' group.

Paired t-test comparisons examined differences between current and planned behaviors after using the Germ Defence website. Mean difference scores for each group and 95% confidence intervals are reported in Table 4. The difference between intended and current behavior was largest for cleaning/disinfecting (M 0.38, 0.37 to 0.39) and putting aside shopping/packages (M 0.49, 0.47 to 0.50), and lowest for self-isolating (M 0.15, 0.14 to 0.16). Overall, infection control behaviors increased (M 0.30, 0.29 to 0.31).

Handwashing behavior is reported in Table 5. Mean current handwashing behavior was higher than other infection control behaviors (M 4.04, SD 0.84) with reported intended behavior consistently higher (Mean increase 0.41, 95%CI 0.40 to 0.42).

Table 3. Current and intended infection control behaviors.

Group	**Protect themselves generally (N 18,029)**	**Protect others if user showing symptoms (N 169)**			**Protect themselves if household member showing symptoms (N 319)**			**Protect a household member at high risk (N 1,787)**		
Current behavior	***M (SD)***	***M (SD)***	***MD (95% CI)***	***d***	***M (SD)***	***MD (95% CI)***	***d***	***M (SD)***	***MD (95% CI)***	***d***
Socially distance	2.39 (1.22)	2.52 (1.39)	0.13 (-0.07 to 0.33)	0.11	2.57 (1.23)	0.17 (0.04 to 0.31)	0.15	2.51 (1.20)	0.12 (0.06 to 0.18)	0.10
Clean /disinfect	3.18 (1.18)	2.95 (1.26)	-0.24 (-0.42 to -0.06)	0.20	3.05 (1.18)	0.17 (0.04 to 0.31)	0.11	3.19 (1.17)	0.003 (-0.05 to 0.06)	0.00
Put aside shopping / packages	2.74 (1.55)	2.39 (1.48)	-0.35 (-0.60 to -0.11)	0.23	3.00 (1.49)	0.26 (0.08 to 0.44)	0.17	2.82 (1.59)	0.08 (0.004 to 0.16)	0.05
Self- isolate in own room	2.79 (1.30)	2.85 (1.43)	0.05 (-0.15 to 0.25)	0.04	2.75 (1.26)	-0.04 (-0.19 to 0.10)	0.03	2.64 (1.16)	-0.15 (-0.21 to -0.08)	0.11
Wear face covering	1.63 (1.21)	1.91 (1.36)	0.28 (0.07 to 0.49)	0.24	1.75 (1.28)	0.12 (-0.02 to 0.27)	0.10	1.42 (0.99)	-0.21 (-0.27 to -0.14)	0.17
Overall behavior score[a]	2.67 (0.91)	2.61 (1.08)	-0.05 (-0.19 to 0.08)	0.06	2.68 0.90)	0.01 (-0.09 to 0.11)	0.01	2.59 (0.80)	-0.07 (-0.12 to-0.03)	0.08
Intended Behavior	***M (SD)***	***M (SD)***	***MD (95% CI)*** [b]	***d***	***M (SD)***	***MD (95% CI)*** [b]	***d***	***M (SD)***	***MD (95% CI)*** [b]	***d***
Socially distance	2.63 (1.28)	2.79 (1.47)	0.05 (-0.06 to 0.16)	0.12	2.88 (1.30)	0.12 (0.05 to 0.20)	0.19	2.84 (1.27)	0.11 (0.07 to 0.14)	0.16
Clean /disinfect	3.57 (1.16)	3.18 (1.33)	-0.14 (-0.25 to -0.03)	0.33	3.46 (1.18)	0.001 (-0.08 to 0.08)	0.09	3.63 (1.15)	0.05 (0.01 to 0.08)	0.05
Put aside shopping / packages	3.24 (1.52)	2.73 (1.59)	-0.19 (-0.34 to -0.04)	0.34	3.44 (1.41)	-0.02 (-0.12 to 0.09)	0.13	3.37 (1.52)	0.06 (0.01 to 0.11)	0.08
Self- isolate in own room	2.94 (1.28)	3.08 (1.41)	0.10 (0.02 to 0.18)	0.12	2.97 (1.23)	0.07 (0.01 to 0.13)	0.03	2.87 (1.17)	0.06 (0.04 to 0.09)	0.05
Wear face covering	1.95 (1.37)	2.19 (1.50)	0.03 (-0.11 to 0.17)	0.18	2.15 (1.47)	0.08 (-0.01 to 0.18)	0.15	1.82 (1.28)	0.08 (0.03 to 0.12)	0.09
Overall behavior score[a]	2.97 (0.96)	2.86 (1.20)	-0.03 (-0.12 to 0.05)	0.11	3.01 (0.96)	0.03 (-0.03 to 0.09)	0.04	2.97 (0.89)	0.06 (0.03 to 0.08)	0.00

Note: Between group comparisons compare each group to the 'Protect themselves generally' group.

Scale: 1) Almost never; 2) Sometimes; 3) Quite often; 4) Very often; 5) Almost always.

M = mean, SD = standard deviation, CI = confidence interval, d = Cohen's d (reported as the standardized mean difference between the each group and the comparison group).

[a] Overall behavior scores are means calculated from all behaviors in which a response was recorded.
[b] Controlling for current behavior.

Table 4. Group differences between behavior and intention.

	Group									
	Protect themselves generally (N 18,029)		**Protect others if user showing symptoms (N 169)**		**Protect themselves if household member showing symptoms (N 319)**		**Protect a household member at high risk (N 1,787)**		**Overall**	
Behavior	***MD (95% CI)***	***d***	***MD (95% CI)***	***d***	***MD (95% CI)***	***d***	***MD (95% CI)***	***d***	***MD (95% CI)***	***d***
Socially distance	0.22 (0.21 to 0.23)	0.35	0.26 (0.11 to 0.40)	0.30	0.33 (0.24 to 0.42)	0.41	0.31 (0.28 to 0.35)	0.43	0.23 (0.22 to 0.24)	0.36
Clean / disinfect	0.38 (0.37 to 0.39)	0.52	0.30 (0.17 to 0.44)	0.36	0.41 (0.31 to 0.51)	0.47	0.43 (0.39 to 0.47)	0.54	0.38 (0.37 to 0.40)	0.52
Put aside shopping / packages	0.49 (0.47 to 0.50)	0.49	0.39 (0.24 to 0.54)	0.42	0.41 (0.31 to 0.51)	0.47	0.53 (0.48 to 0.58)	0.50	0.49 (0.47 to 0.50)	0.49
Self-isolate in own room	0.14 (0.13 to 0.15)	0.28	0.23 (0.11 to 0.36)	0.30	0.21 (0.14 to 0.29)	0.33	0.22 (0.19 to 0.25)	0.34	0.15 (0.14 to 0.16)	0.29
Wear face covering	0.28 (0.27 to 0.30)	0.37	0.29 (0.12 to 0.47)	0.30	0.35 (0.25 to 0.46)	0.42	0.37 (0.33 to 0.42)	0.42	0.29 (0.28 to 0.29)	0.37
Average infection control score	0.29 (0.29 to 0.30)	0.53	0.27 (0.16 to 0.38)	0.38	0.32 (0.25 to 0.40)	0.49	0.36 (0.33 to 0.39)	0.57	0.30 (0.29 to 0.31)	0.53

Note: Group Ns are taken across all behaviors.

Table 5. Paired comparisons between current and intended hand washing behavior.

Handwashing situation	**Current behavior (N 12,981)** ***M (SD)***	**Intended behavior (N 12,981)** ***M (SD)***	**MD (95% CI)**	**d**
Before eating snacks	3.91 (1.28)	4.45 (0.99)	0.54 (0.52 to 0.56)	0.54
After coming home	4.66 (0.81)	4.80 (0.62)	0.14 (0.13 to 0.15)	0.26
After sneezing or coughing	3.45 (1.43)	4.11 (1.23)	0.66 (0.64 to 0.68)	0.59
After contact with possible	4.22 (1.24)	4.53 (1.00)	0.30 (0.29 to 0.32)	0.36

carrier				
After touching something	4.13 (1.23)	4.50 (0.97)	0.36 (0.35 to 0.38)	0.43
Overall score	4.00 (1.03)	4.34 (0.91)	0.34 (0.33 to 0.35)	0.50

Note: Hand washing overall score was a separate item

Discussion

Summary of findings

Germ Defence was accessed by a large number of users across 129 countries, primarily from the UK. This demonstrates substantial public interest in adopting appropriate infection control behaviors in the home during the COVID-19 pandemic. After using Germ Defence, all groups reported intentions to increase the frequency of their infection control behaviors, including handwashing.

Except for handwashing, self-reported infection control behaviors in the home were only reported 'sometimes/quite often' regardless of whether people were seeking to protect themselves, concerned about demonstrating COVID-19 symptoms, had a household member showing symptoms, or were seeking to protect a high-risk household member. The frequency of wearing face coverings was consistently the lowest of the behaviors, while cleaning/disinfecting was the most frequently reported of the behaviors outside of handwashing. All of these infection control behaviors were reported to be performed much less frequently than was handwashing.

As would be expected, certain behaviors and intentions varied according to the circumstances of groups – for example, people seeking to protect others when showing symptoms reported higher current frequencies of wearing face-coverings, while people seeking to protect a high-risk household member reported the intention to socially distance within the home more frequently.

Comparison with existing literature

This study provides the first up-to-date analysis of infection control behaviors and intentions across the UK, in a large sample during the COVID-19 pandemic. Within-household transmission will be increasingly important as infection control measures become established in external, public environments [6,19]. Therefore, understanding current infection control behaviors within homes (and how to improve them) is vital to continue to control the pandemic.

Self-reported infection control behaviors other than handwashing are lower than is optimal for infection prevention; even in Germ Defence users who were likely more motivated and more likely to engage in protective behaviors than the general population (as they were seeking additional information) [20]. Increasing engagement in these behaviors is important as societal restrictions are released and perceived risk reduces [21].

Germ Defence users reported intentions to increase the frequency of infection control behaviors over their current rates. Although such intentions potentially misrepresent the observed behavioral change after an intervention (the 'intention-behavior gap' [22]) our evidence suggests

that Germ Defence may overcome this. Analysis of comparable data from the PRIMIT trial handwashing intervention showed slightly smaller behavior/intention differences (effect size d 0.45). This change was sufficient to cause reduced infection transmission and severity within households after 16 weeks [12]. Comparable data during the current pandemic (Reducing Illness behaviors d 0.53; Handwashing d 0.50) shows a slightly larger effect across a broader range of behaviors that may have a larger impact on infection rates.

Study limitations

As a cross-sectional observation of an active intervention, Germ Defence lacks longitudinal follow-up. Care must be taken when interpreting findings within the rapidly changing context of the COVID-19 pandemic. Our method of categorization using website pathways may not be accurate for some users, or might overlook individual differences within categories.

Our data may not be a representative sample from the wider UK population, for several reasons. Firstly, users of Germ Defence are likely to be more motivated and report higher frequencies of infection control behaviors. Secondly, although analytic data indicates that the large majority of users of the intervention were from the UK, we could not identify non-UK users within behavioral data. Finally, self-reported infection control behaviors may not be accurate reflections of actual behaviors occurring within households.

However, none of these limitations affect our main findings; indeed, people are prone to over-report protective behaviors, further highlighting the need for improvement.

Implications for practice and research

A concerted effort to improve household infection control behaviors across the UK population is likely to be an efficient use of health resource, both to reduce current rates of infection and to prevent the likelihood and severity of future outbreaks. Handwashing behaviors are already relatively high – perhaps due to existing familiarity with the behavior, supported by a focus in public health advice on increasing handwashing in earlier stages of the pandemic. Therefore recommending digital interventions such as Germ Defence to target other infection control behaviors within the home may help control the current pandemic.

Given the current rates of infection control behaviors within the home, even within a motivated sample, it is vital to address barriers to engaging in them. For example, people living in crowded, working households are more likely to come into contact with the virus [5], and may also find it difficult to self-isolate. Similarly, cultural differences, financial challenges, or caring responsibilities may cause barriers to social distancing [6]. Research should explore how to support these behaviors for as many households as

possible. Indeed, digital interventions such as Germ Defence can use tailored content to target behaviors that are relevant for specific user groups.

Conclusion

Our findings show substantial room for improvement in protective behaviors across the UK – even in our motivated, self-selected sample – as societal restrictions are eased. People are not sufficiently self-isolating within the home in order to prevent household transmission, even when a household member or they themselves are demonstrating COVID-19 symptoms. Promoting evidence-based behavior change interventions might improve these behaviors, reducing transmission within households and the incidence/severity of infections.

Germ Defence is a scalable, evidence-based, acceptable and free public health intervention with negligible safety risk, which could be included in public heath guidance and promoted via primary care networks at minimal cost for wide population coverage.

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Competing Interests

All authors have completed the **Unified Competing Interest form** (available on request from the BA) and declare: no support from any organization for the submitted; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

Contributors

Conceived the study: BA, SM, LY.
Study Design: BA, LY.
Analyzed the data: BA, BS, JG.
Interpreted the data: All authors
Developed the intervention: All authors
Drafted the manuscript: BA
Reviewed the manuscript and approved the content: All authors
Met authorship criteria: All authors.

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interpretation of data or in writing the manuscript.

Ethics and Data-sharing statement

Consent was assumed from website usage and acknowledged in the website privacy policy. All data was collected in line with General Data Protection Regulation (GDPR) EU Law. The study received ethical approval from University of Bath (PREC reference 20-088). All time-stamped data files used in analysis (and analysis scripts) are available [23]. *Note for reviewers; this link will be finalised in final manuscript)*.

Transparency Declaration

The lead authors (BA and LY) confirm that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and any discrepancies have been explained.

Dissemination

It is not possible to disseminate these results to study participants as they are anonymous.

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Abbreviations

CI: Confidence Interval

CR: Co-author Cathy Rice

JB: Co-author Jennifer Bostock

M: Mean

RTI: Respiratory tract infection

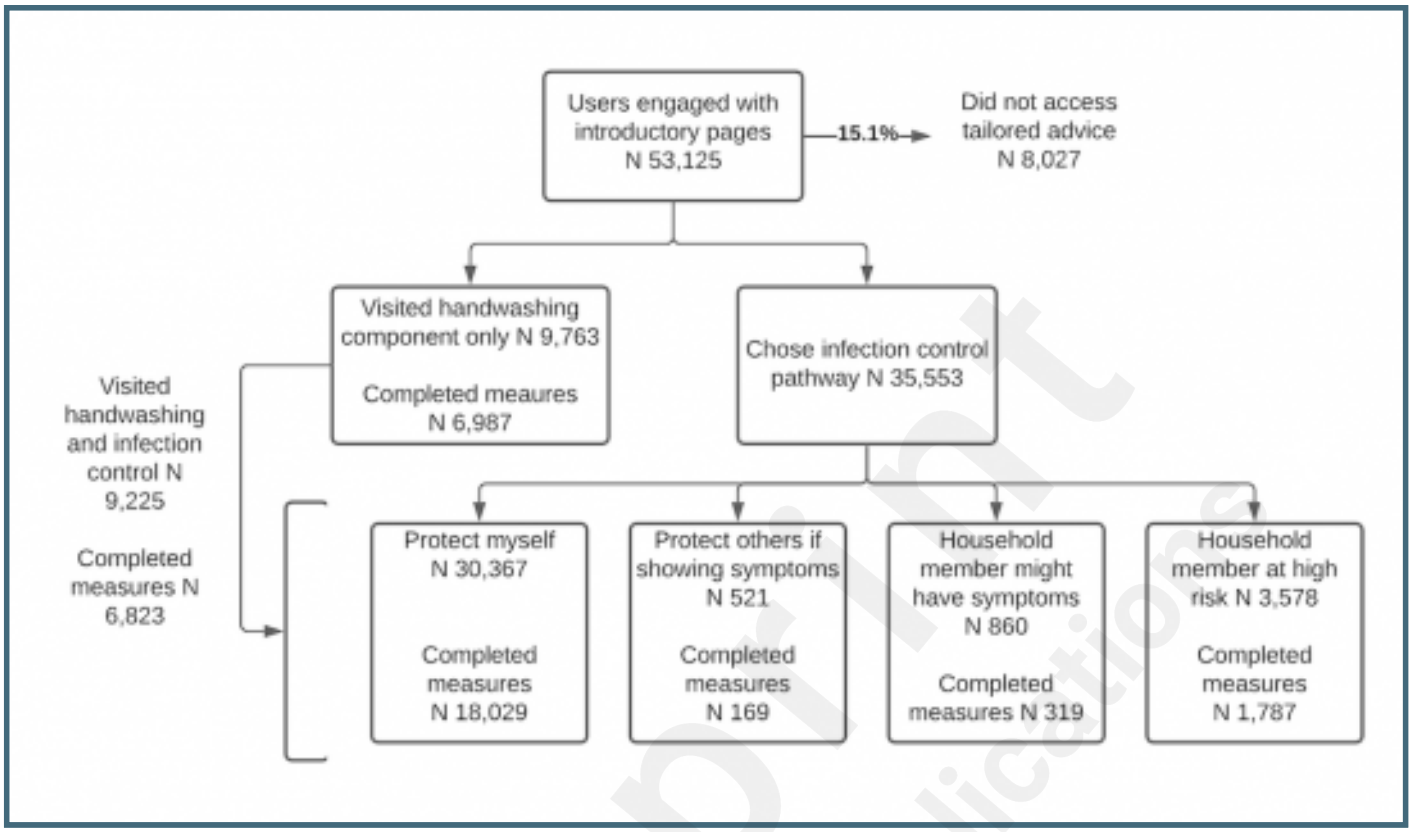
SD: Standard Deviation

UK: United Kingdom

Supplementary Files

Figures

Consort diagram of Germ Defence website usage (and group categorization).



Multimedia Appendixes

Comparison of aggregated usage statistics for users outside of the UK (compared to users within the UK).
URL: https://asset.jmir.pub/assets/e5ad4cf5505cb3b25e470eafc657b60a.docx

CONSORT (or other) checklists

Confirmation of Strobe Checklist for observational study.
URL: https://asset.jmir.pub/assets/4e754bb7839aa5ae374e2d32f4a73a74.pdf