A systematic review and realist synthesis on toilet paper hoarding: COVID or not COVID, that is the question

Javier Labad [Corresp., 1, 2], Alexandre González-Rodríguez [3], Jesus Cobo [2, 3, 4], Joaquim Puntí [3], Josep Maria Farré [5]

[1] Department of Mental Health, Consorci Sanitari del Maresme, Mataró, Spain

[2] Centro de Investigación Biomédica en Salud Mental (CIBERSAM)., Madrid, Spain

[3] Department of Mental Health, Parc Taulí Hospital Universitari, Sabadell, Spain

[4] Department of Psychiatry and Legal Medicine, Universitat Autónoma de Barcelona, Cerdanyola del Vallès, Spain

[5] Department of Psychiatry, Psychology and Psychosomatics, Dexeus University Hospital, Barcelona, Spain

Corresponding Author: Javier Labad
Email address: jlabad@csdm.cat

Objective. To explore whether the coronavirus disease 2019 (COVID-19) pandemic is associated with toilet paper hoarding and to assess which risk factors are associated with the risk of toilet paper hoarding. **Design.** A systematic review and realist review were conducted. **Data sources.** PubMed, Web of Science, Scopus and PsycINFO were searched for the systematic review. PubMed and grey literature were searched for the realist review. Databases were searched from inception until June 2020. **Study selection.** There were no restrictions on study design. **Outcomes and measures.** For the systematic review, toilet paper hoarding was the main outcome, and inadequate use of toilet paper was the secondary outcome. For the realist review, the CMO (context-mechanisms-outcome) scheme included the COVID-19 pandemic (context), four proposed mechanisms, and one outcome (toilet paper hoarding). The four potential mechanisms were: 1) gastrointestinal mechanism of COVID-19 (e.g., diarrhoea), 2) social cognitive biases, 3) stress-related factors [mental illnesses, personality traits], and 4) cultural aspects (e.g., differences between countries). **Eligibility criteria for selecting studies.** All human populations were considered (including general population studies and clinical studies of patients suffering from mental health problems). **Results.** The systematic review identified 11 studies (5 studies for the main outcome, 6 studies for the secondary outcome). Two surveys identified the role of the COVID-19 threat on toilet paper hoarding in the general population (one in adults, another in adolescents). One study pointed to an association between a personality trait (conscientiousness) and toilet paper buying and stockpiling as well as an additional significant indirect effect of emotionality through perceived threat of COVID-19 on toilet paper buying and stockpiling. Six case reports of inadequate use of toilet paper were also identified, although none of them were associated with the

COVID-19 pandemic. The realist review suggested that of all mechanisms, social cognitive biases and a bandwagon effect were potential contributors of toilet paper hoarding in the general population. The stressful situation (COVID-19 pandemic) and some personality traits (conscientiousness) were found to be associated with toilet paper hoarding. Cultural differences were also identified, with relatively substantial effects of toilet paper in several Asian regions (Australia, Japan, Taiwan and Singapore). **Conclusions.** The COVID-19 pandemic has been associated with a worldwide increase in toilet paper hoarding. Social media and social cognitive biases are major contributors and might explain some differences in toilet paper hoarding between countries. Other mental health-related factors, such as the stressful situation of the COVID-19 pandemic and fear of contagion, or particular personality traits (conscientiousness) are likely to be involved. **Registration.** PROSPERO CRD42020182308

A systematic review and realist synthesis on toilet paper hoarding: COVID or not COVID, that is the question

Javier Labad[1,2], Alexandre González-Rodríguez[3], Jesús Cobo[2,3,4], Joaquim Puntí[3] and Josep Maria Farré[5]

on behalf of the Catalan Toilet Tissue Research Group in Mental Health (CATOTIM).

[1]Department of Mental Health, Consorci Sanitari del Maresme. Mataró, Spain.

[2]Centro de Investigación Biomédica en Salud Mental (CIBERSAM). Spain.

[3]Department of Mental Health, Parc Taulí Hospital Universitari, I3PT. Sabadell, Spain.

[4]Department of Psychiatry and Legal Medicine, Universitat Autònoma de Barcelona. Cerdanyola del Vallès, Spain.

[5]Department of Psychiatry, Psychology and Psychosomatics, Dexeus University Hospital. Barcelona, Spain

Corresponding Author:
Javier Labad
Department of Mental Health, Consorci Sanitari del Maresme
Carr. de Cirera, 230, 08304 Mataró, Spain
Email: jlabad@csdm.cat

Abstract

Objective. To explore whether the coronavirus disease 2019 (COVID-19) pandemic is associated with toilet paper hoarding and to assess which risk factors are associated with the risk of toilet paper hoarding.
Design. A systematic review and realist review were conducted.
Data sources. PubMed, Web of Science, Scopus and PsycINFO were searched for the systematic review. PubMed and grey literature were searched for the realist review. Databases were searched from inception until June 2020.
Study selection. There were no restrictions on study design.
Outcomes and measures. For the systematic review, toilet paper hoarding was the main outcome, and inadequate use of toilet paper was the secondary outcome. For the realist review, the CMO (context-mechanisms-outcome) scheme included the COVID-19 pandemic (context), four proposed mechanisms, and one outcome (toilet paper hoarding). The four potential mechanisms were: 1) gastrointestinal

36 mechanism of COVID-19 (e.g., diarrhoea), 2) social cognitive biases, 3) stress-related factors [mental
37 illnesses, personality traits], and 4) cultural aspects (e.g., differences between countries).
38 **Eligibility criteria for selecting studies.** All human populations were considered (including general
39 population studies and clinical studies of patients suffering from mental health problems).
40 **Results.** The systematic review identified 11 studies (5 studies for the main outcome, 6 studies for the
41 secondary outcome). Two surveys identified the role of the COVID-19 threat on toilet paper hoarding in
42 the general population (one in adults, another in adolescents). One study pointed to an association
43 between a personality trait (conscientiousness) and toilet paper buying and stockpiling as well as an
44 additional significant indirect effect of emotionality through perceived threat of COVID-19 on toilet
45 paper buying and stockpiling. Six case reports of inadequate use of toilet paper were also identified,
46 although none of them were associated with the COVID-19 pandemic. The realist review suggested that
47 of all mechanisms, social cognitive biases and a bandwagon effect were potential contributors of toilet
48 paper hoarding in the general population. The stressful situation (COVID-19 pandemic) and some
49 personality traits (conscientiousness) were found to be associated with toilet paper hoarding. Cultural
50 differences were also identified, with relatively substantial effects of toilet paper in several Asian regions
51 (Australia, Japan, Taiwan and Singapore).
52 **Conclusions.** The COVID-19 pandemic has been associated with a worldwide increase in toilet paper
53 hoarding. Social media and social cognitive biases are major contributors and might explain some
54 differences in toilet paper hoarding between countries. Other mental health-related factors, such as the
55 stressful situation of the COVID-19 pandemic and fear of contagion, or particular personality traits
56 (conscientiousness) are likely to be involved.
57 **Registration.** PROSPERO CRD42020182308
58

Introduction

59

60 Toilet paper, sometimes called toilet tissue or loo roll, is defined by the Merriam-Webster dictionary as "a
61 thin sanitary absorbent paper usually in a roll for use in drying or cleaning oneself after defecation and
62 urination". To wipe is human, and the use of paper for faecal-related cleaning purposes has been used
63 since the end of the 6th century in China, although the toilet paper industry blossomed in the early 14th
64 century in China during the reign of the Yang dynasty (Smyth, 2012). The commercial use of toilet paper
65 started in 1857 thanks to Joseph Gayetty, a New York-based entrepreneur who sold medicated paper
66 impregnated with aloe that aimed to cure haemorrhoids (Smyth, 2012). The reception of toilet paper from
67 the medical community was not positive, and in an ironic note published in the Lancet in 1869, the idea of
68 toilet paper was defined as "the last absurdity" ("Notes, Short Comments, and Answers to
69 Correspondents: Medicated paper," 1869). The note was sarcastic when referring to Gayetty's opinion,
70 who anticipated that "this article will be found in the household of every refined man in the kingdom".
71 Many years later, toilet paper has become an essential product for a great proportion of the population
72 worldwide.
73 Since early December 2019, the coronavirus SARS-CoV-2 has spread from Wuhan (China) to many
74 countries all over the world, causing the coronavirus disease (COVID-19). With no doubt, the COVID-19
75 has been the worse pandemic since the 1918 flu pandemic, also known as the Spanish flu (although its
76 origin was in Kansas, USA (Worobey, Cox & Gill, 2019)). By August 11th, 2020, the COVID-19
77 pandemic has caused at least 20,420,359 infections and 742,362 deaths ("COVID-19 Coronavirus
78 Pandemic"). During the first months of the pandemic, medical masks were in short supply in most
79 countries. This was an expected issue because the SARS-CoV-2 is viable and infectious in aerosols for
80 hours (van Doremalen et al., 2020), and there is advice to use face masks in situations where meeting
81 others is likely, as masks could reduce the risk of transmitting the infection (Greenhalgh et al., 2020). The
82 global toilet paper shortage amid the coronavirus was much less expected, but in the weeks that followed
83 the pandemic spread, compulsive panic buying of toilet paper was observed in many countries on
84 different continents (Buchholz, 2020). Toilet paper became a co-star with coronavirus in the news in
85 many countries, with surprising information every week: rationing of toilet paper by supermarkets ("UK
86 supermarkets ration toilet paper to prevent stockpiling," 2020), toilet rolls being chained to their
87 dispensers in public toilets ("In Japan, toilet rolls are being chained to their dispensers," 2020), armed
88 robbers stealing hundreds of paper rolls ("Coronavirus: Armed robbers steal hundreds of toilet rolls in
89 Hong Kong," 2020), and deserted supermarket and grocery shelves (Knoll, 2020). People were buying
90 and hoarding toilet paper even before it was known that the virus could be detected in faeces of infected
91 patients (Chen et al., 2020a) or that approximately 10% of COVID-19 patients may suffer from diarrhoea
92 (Miri et al., 2020). Therefore, a scientific question demands an urgent response: why do people hoard
93 toilet paper?
94 We aimed to shed light on potential risk factors associated with toilet paper hoarding, with a particular
95 interest in stress-related situations such as the COVID-19 pandemic. As hoarding is often seen in patients
96 with obsessive-compulsive disorder (OCD) and other psychiatric disorders as well as in people with
97 obsessive-compulsive traits (Mataix-Cols et al., 2010), it is important to make the differential diagnosis
98 with mental health problems. In most individuals, compulsive hoarding appears to be a distinct syndrome
99 from OCD, which is associated with substantial levels of disability and social isolation (Pertusa et al.,
100 2008). This has led to include hoarding as a separate diagnosis in the 5th edition of the Diagnostic and
101 Statistical Manual of Mental Disorders (DSM-5). One hoarding criterion is the acquisition of and failure
102 to discard a large number of possessions that seem to be useless or of limited value (Mataix-Cols et al.,

103   2010). We do not want to open the debate about the utility of toilet paper right now, but it is important to
104   mention that to date, toilet paper is not a specifier of the DSM-5 diagnostic criteria for hoarding.
105   Epidemiological studies suggest that hoarders are older, often unmarried, and are more likely to be
106   impaired by a current physical health condition or comorbid mental disorder (Nordsletten et al., 2013).
107   There is limited information regarding the prevalence of toilet paper hoarding in the general population.
108   It is also important to underscore that compulsive buying and hoarding are two related phenomena, as
109   hoarding is a predictor of compulsive buying (Lawrence, Ciorciari & Kyrios, 2014). Moreover, people
110   with buying-shopping disorder report more hoarding symptoms than healthy control individuals (Vogel et
111   al., 2019). Both buying and hoarding conducts have been described to be preceded by stressful life events
112   and traumatic experiences (Tolin et al., 2010; Landau et al., 2011; Vogel et al., 2019). For this reason, it is
113   important to study how stress influences hoarding behaviour because this knowledge would help to
114   understand some of the recent panic-buying conduct seen in the weeks following the COVID-19
115   pandemic. As hoarding behaviours are observed in both non-clinical (Bulli et al., 2014) and clinical
116   (Pertusa et al., 2008) samples, studies considering non-clinical populations need to be considered. It is
117   also important to analyse whether the mechanisms linking stress with toilet paper hoarding are shared by
118   people with mental disorders (hoarding disorders and other psychiatric disorders) and the general
119   population, or whether this relationship might change depending upon the social or cultural context.
120   The main objective of our study was to identify potential mechanisms linking the context of a stressful
121   situation (COVID-19 pandemic) with a specific outcome (toilet paper hoarding). We hypothesized that
122   these mechanisms might be influenced by psychopathological, psychological, social and cultural
123   determinants that could act as moderators. For achieving these approaches, we aimed to conduct one
124   study that included several sequential steps:
125   First, we aimed to conduct a systematic review exploring potential risk factors associated with toilet paper
126   hoarding. Psychopathology, personality and stress-related factors (including pandemics and especially,
127   the COVID-19 pandemic) were considered. As a secondary aim of the systematic review, we also wanted
128   to study whether toilet paper use (inadequate use and/or hoarding) is associated with negative mental
129   health outcomes (e.g., greater risk of depression, suicide, etc.).
130   Second, we aimed to conduct a realist review exploring different theory-driven mechanisms on potential
131   moderators of the relationship between the COVID-19 pandemic and the toilet paper hoarding (Table 1).
132   A realist review is based on a realist philosophy of science and considers the interaction between context,
133   mechanism and outcome, also known as the CMO configuration (Wong et al., 2013). As explained in the
134   RAMESES guidelines for realist syntheses (Wong et al., 2013), this type of review uses the concept of
135   mechanism for understanding the relationship between context and outcome. Several mechanisms might
136   be studied, which can be defined as "underlying entities, processes, or (social) structures which operate in
137   particular contexts to generate outcomes of interest".
138   Third, we wanted to integrate the previous information for proposing a pilot algorithm for managing toilet
139   paper hoarding, taking into account the expertise of members of the Catalan Toilet Tissue Research
140   Group in Mental Health (CATOTIM). Although a validation study for this algorithm has not been
141   included and therefore our algorithm should be considered a theoretical proposal, it is the first attempt to
142   integrate the complexity of this specific hoarding conduct in the current COVID-19 context.
143   Finally, several recommendations for future research will be included considering the gaps in the
144   scientific literature. Clinical and ecological implications of our research will also be summarized.
145   **Materials & Methods**
146   **Systematic review**

147 Search strategy

148 Four electronic bibliographic databases were searched: PubMed, Web of Science, Scopus and

149 PsycINFO. The following search strategy was used: (Toilet AND (paper OR tissue)) AND

150 (psychiatry OR psychology OR mental OR anxiety OR depression OR schizophrenia OR bipolar

151 OR psychosis OR delusion OR personality OR neuroticism OR obsessive OR hoarding OR

152 suicide OR stress* OR pandemic OR epidemic OR COVID-19 OR coronavirus OR virus).

153 Language was restricted to those articles written English, Spanish, Catalan, Portuguese, Dutch,

154 French, and German. Studies published until June 2020 were considered for inclusion. The

155 protocol was registered in PROSPERO (CRD42020182308). Preferred Reporting Items for

156 Systematic Reviews and Meta-analyses (PRISMA) guidelines (Moher et al., 2009) were

157 followed.

158 Inclusion and exclusion criteria

159 In our systematic review, toilet paper hoarding was considered as the main outcome. This

160 outcome was defined as a behavioural pattern characterized by excessive acquisition of and an

161 inability or unwillingness to discard large quantities of toilet paper that cause significant distress

162 or impairment. This definition is in agreement with the current DSM-5 diagnostic category for

163 hoarding disorder but it has been adapted for specifying that the main saved item is toilet paper.

164 We also conducted a secondary analysis for the systematic review considering toilet paper

165 (inadequate use or hoarding) as a risk factor of mental health outcomes (depression, suicide,

166 etc.).

167 In those studies using toilet paper as an outcome (e.g., toilet paper hoarding), all potential

168 exposures (stress-related situations, personality factors, psychopathology, and mental illnesses)

169 were considered. In those studies using the use of toilet paper as an exposure, considered

170 outcomes were mental health problems (e.g., depression, suicide, etc.).

171 All types of studies that relate to mental health or stress-related aspects of toilet paper use were

172 included. There were no restrictions on the types of study design. All studies conducted in

173 human populations (general population studies and clinical studies of patients suffering from

174 mental health problems) were considered for inclusion.

175 Data collection and extraction

176 All retrieved records were checked for duplicates using Covidence (https://www.covidence.org/).

177 Titles and/or abstracts of studies retrieved using the search strategy and those from additional

178 sources were screened independently by two review authors (J.L. and A.G.R.) to identify studies

179 that met the inclusion criteria. Any disagreement between them over the eligibility of particular

180 studies was resolved through discussion with two additional reviewers. The flow chart of all

181 selected studies is described in Figure 1.

182

183 Risk of bias (quality) assessment

184 Quality assessment was conducted with the Newcastle Ottawa scale (cohort and case–control

185 studies) (Wells et al., 2012) or the CARE guidelines (case reports) (Riley et al., 2017). Case

186 reports and case series are also rated with the tool for evaluating the methodological quality of
187 case reports and case series (Murad et al., 2018).
188
189 **Realist review**
190 A realist synthesis was conducted following the RAMESES guidelines (Wong et al., 2013). An
191 additional reviewer (J.C.) participated in the search of potential citations along with the two
192 researchers participating in the systematic review (J.L. and A.G.R.). We started by considering
193 all reviewed items in the previous step with the theory-driven approach of the realist review.
194 Four mechanisms were tested (Table 1). Iterative screening was completed by these reviewers
195 who also conducted additional searches for exploring these hypotheses on PubMed as well as
196 grey literature available on the internet (e.g., Google searching). Search terms differed for each
197 mechanism: 1) Mechanism 1: covid AND (diarrhoea OR polyuria); 2) Mechanism 2: (stress OR
198 covid OR pandemic) AND cognitive bias AND social; 3) Mechanism 3: (covid OR stress OR
199 pandemic) AND hoarding; 4) Mechanism 4: (toilet paper OR hoarding) AND (culture OR
200 cultural). All potential abstracts were included if they could contribute to explain any of the four
201 studied mechanisms linking the COVID-19 pandemic with toilet paper hoarding. Identification
202 and selection of citations was guided for these research questions and was concerned with
203 trustworthiness. This last characteristic is not an easy one to verify, as fake news is mixed with
204 real news all over the internet. We tried to reduce the inclusion of fake news by a careful
205 observation of the sources, particularly when they came from non-peer-reviewed sources.
206
207 For exploring differences in cultural aspects of toilet paper hoarding, we also verified the Google
208 search trending topics during the year of 2020 in the world (https://trends.google.com/). Previous
209 research indicates that Google search data are useful in predicting near-future consumer
210 behaviour (Goel et al., 2010). The search frequency on Google has also been proposed as a direct
211 measure of investor attention (Da, Engelberg & Gao, 2011). Data regarding the use of toilet
212 paper was graphed with Excel (Microsoft Corporation, USA) after downloading the .csv file. We
213 also compared two search terms (toilet paper vs covid), to analyse the relative popularity of the
214 term 'toilet paper' with respect to the 'covid' term.
215 Qualitative studies and material were managed with the software QDA miner Lite version 2.0.7
216 (Provalis Research, Canada). Data regarding the potential contribution of studied mechanisms
217 were extracted. To identify key elements of importance to the success or failure of a mechanism
218 in a certain context using a realist perspective, information was gathered on the mechanism, the
219 context and the actual "working of the mechanism". The strength of the evidence and the
220 usefulness of the application of realist principles to available data were discussed.
221
222 **CATOTIM algorithm for managing paper toilet hoarding**
223 All authors participated in the generation of a proposal of an algorithm for managing toilet paper
224 hoarding. All CATOTIM researchers are specialists in Psychiatry and/or Clinical Psychology.
225 The generation of the algorithm was a dynamic process. The methodology for drafting and

226   reviewing the algorithm included whatsapp conversations, face-meetings taking into account all
227   needed safety measures recommended for the COVID-19 situation by the Spanish Ministry of
228   Health (social distance of at least 1.5 metres, surgical masks, pre- and post- meeting hand
229   washing), and online meetings when necessary. Successive versions of the algorithm were
230   created taking into account the findings of the systematic and realist reviews and the comments
231   from all CATOTIM members.
232
233   Results
234   **Systematic review**
235   A total of 799 records were identified in initial searches (Web of Science: 425; Scopus: 218,
236   PubMed: 93; PsycINFO: 63). After duplications were removed, 466 records were screened.
237   Further details of screening and selection processes can be found in Figure 1. Finally, 11 studies
238   were included as they were focused on toilet paper hoarding behaviour and met our selection
239   criteria.
240   Primary outcome: toilet paper hoarding
241   We identified five published studies related to the COVID-19 pandemic with toilet paper
242   hoarding (Garbe, Rau & Toppe, 2020; Kirk & Rifkin, 2020; Oosterhoff & Palmer, 2020; Sim et
243   al., 2020; Miri et al., 2020). One study included a survey of participants focused on toilet paper
244   shopping and stockpiling behaviours (Garbe, Rau & Toppe, 2020), another study conducted a
245   survey of adolescents regarding several pandemic-related behaviours (including hoarding)
246   (Oosterhoff & Palmer, 2020), whereas the other three published studies included theoretical
247   discussions on consuming behaviours including panic buying during the COVID-19 pandemic
248   (Kirk & Rifkin, 2020; Sim et al., 2020; Miri et al., 2020).
249   The first study (Garbe, Rau & Toppe, 2020) explored the relationship between personality traits
250   based on the HEXACO model (Honesty-Humility, Emotionality, eXtraversion, Agreeableness,
251   Conscientiousness, and Openness to experience). This study was a survey that included a final
252   sample of 996 adults from 22 countries. Participants were asked about their perceived level of
253   threat posed by COVID-19, and their toilet paper consumption behaviour (shopping frequency,
254   shopping intensity, number of toilet paper rolls stocked in their household). Older participants
255   shopped more frequently, bought more packages of toilet paper and had more toilet paper rolls in
256   stock as compared to younger participants. Participants residing in Europe significantly shopped
257   toilet paper more frequently than North American residents but had less toilet paper in stock. In
258   this study, participants were inquired about whether they stocked toilet paper more than usual,
259   which could be considered an indirect measure of toilet paper hoarding. Of all participants in the
260   survey, 17.2% of North Americans and 13.7% of Europeans reported excessive stockpiling of
261   toilet paper. The perceived threat of COVID-19 was positively related to all three toilet paper
262   variables (shopping frequency, shopping intensity and toilet paper stock-pilling). The HEXACO
263   model suggested that participants scoring high in conscientiousness (organization, diligence,
264   perfectionism, and prudence) shopped more toilet paper and stocked more toilet paper. This
265   study also included an additional analysis exploring the indirect effect of emotionality

266 (fearfulness, anxiety, dependence, and sentimentality) on toilet paper consumption. They found a
267 significant indirect effect of emotionality through perceived threat of COVID-19 on shopping
268 intensity and the amount of stocked toilet paper rolls. In the quality assessment with the
269 Newcastle Ottawa Scale for this study, we considered perceived threat of COVID-19 as the main
270 exposure, and toilet paper behaviour as the main outcome (definition of cases). The quality
271 assessment yielded two stars for selection (representativeness of the cases, selection of controls),
272 two stars for comparability and one star for the definition of the exposure. Therefore, this study
273 obtained 5 stars of 9 possible stars in the Newcastle Ottawa Scale.
274 Another survey of 770 adolescents in the United States explored the role of psychological factors
275 in pandemic-related behaviours during the COVID-19 outbreak (social distancing, disinfecting,
276 monitoring the news, hoarding supplies) (Oosterhoff & Palmer, 2020). In this study, attitudes
277 about the greater severity of COVID-19 and greater self-interest values were associated with
278 more hoarding, whereas greater social responsibility and social trust were associated with less
279 hoarding. In the quality assessment with the Newcastle Ottawa Scale for this study, we
280 considered attitudes about the severity of COVID-19 as the main exposure and hoarding
281 behaviour as the main outcome (definition of cases). This study obtained 5 out of 9 stars in the
282 Newcastle Ottawa Scale (selection [two stars], comparability [two stars], definition of exposure
283 [one star]).
284 Two studies made reflections on potential explanations for the toilet paper hoarding amid the
285 COVID-19 pandemic and justified this behaviour with different hypotheses such as a reaction to
286 a threat to product availability that increases the perceived need for the threatened object and
287 making consumers behave with an emotional reactance response (Kirk & Rifkin, 2020). Other
288 potential moderators included the conflict between the desire of maintaining regular routines
289 versus the uncertainty of limiting access to daily necessities by the pandemic, a coping response
290 to stressful unmet situations or even a reaction to the loss of control of the future and social
291 pressures to conform to similar behaviours (Sim et al., 2020). In another systematic review on
292 gastrointestinal symptoms of COVID-19 that indicates the long persistence of COVID-19 in the
293 gastrointestinal tracts after primary treatment (Miri et al., 2020), the authors suggested that these
294 findings could explain the coronavirus panic buy of toilet rolls.
295 We also identified a study (Columbus) that conducted a survey of how personality traits
296 influence food or supply stockpiling during the COVID-19 pandemic that was a pre-print, and
297 therefore not considered for inclusion in the systematic review (it will be included in the realist
298 review).
299
300 Secondary outcome: toilet paper (inadequate use or hoarding) and mental health outcomes
301 Six case reports of inadequate use of toilet paper hoarding were identified. One study reported a
302 case of a patient with therapy-resistant OCD that spent hours on the toilet with excessive anus
303 wiping, using at least 10 rolls of toilet paper per day (Klimke et al., 2016). Interestingly, with
304 only two applications of transcranial alternating current stimulation (tACS), the patient showed
305 immediate improvement (using less that one toilet roll per day).

306 Two case reports completed suicide by mechanical asphyxia using toilet paper: one patient
307 suffering from schizophrenia (Sauvageau & Yesovitch, 2006) and another patient with borderline
308 personality disorder (Saint-Martin, Bouyssy & O'Byrne, 2007). Is it not always easy to
309 distinguish suicide from homicide, and another study reported the case of a homicide by toilet
310 paper smothering in a patient with Alzheimer disease (Saint-Martin, Lefrancq & Sauvageau,
311 2012).
312 Two other case reports described patients with pica, a syndrome characterized by unusual
313 craving for ingestion of either edible or inedible substances, who ate toilet paper (Chisholm &
314 Martin, 1981; Fisher et al., 2014). The diagnosis of this syndrome is a clinical challenge because
315 this conduct might be underreported and is sometimes diagnosed after studying medical
316 complications such as iron deficiency and gastrointestinal bleeding (Fisher et al., 2014). In other
317 cases, biochemical deficiencies need to be studied, because hypozincaemia might be playing a
318 role in the ingestion of toilet paper (Chisholm & Martin, 1981).
319 The description of all six case reports is presented in Table 2. The quality of the studies assessed
320 with the CARE guidelines (Table 2) and the recommendations by Murad et al. (Murad et al.,
321 2018) (Table S1) was good. None of these case reports was related to the COVID-19 pandemic.
322
323 **Realist review**
324 The PubMed search for the four theory-driven mechanisms (M1 to M4, Table 1) included a total
325 of 452 records (M1: 108; M2: 104; M3: 80; M4: 60). After the review by three authors, 85
326 records were selected. Eleven additional records from grey literature were also included.
327
328 COVID-19 disease is associated with diarrhoea (or polyuria), which contributes to the panic
329 buying and toilet paper hoarding (Mechanism #1)
330 Most clinical studies suggest that up to 10% of patients suffering from COVID-19 suffer from
331 diarrhoea (Chen et al., 2020c; Guan et al., 2020; Huang et al., 2020; Jin et al., 2020; Kim et al.,
332 2020; Li et al., 2020b; Liu et al., 2020; Xu et al., 2020b; Zhang et al., 2020b), although some
333 studies reported higher rates, between 15% and 34% (Chen et al., 2020b; Pan et al., 2020; Wang
334 et al., 2020a; Zhao et al., 2020). One study (Lei et al., 2020) comparing the clinical features of
335 patients with COVID-19 in Wuhan and outside Wuhan (Guangzhou, China) reported a greater
336 proportion of diarrhoea in the subsample of patients outside Wuhan (25% vs 2%). Another study
337 suggests that the prevalence of diarrhoea is greater (18.8%) in hospitalized frontline medical
338 workers from Wuhan (Wang et al., 2020b). A recent meta-analysis that included 58 studies with
339 COVID-19 patients with data on the prevalence of diarrhoea reported a pooled prevalence of
340 diarrhoea of 12.5% (95% CI, 9.6–16.0) (Cheung et al., 2020). A similar prevalence (12.9%) was
341 also reported by another meta-analysis including 24 studies (Zhu et al., 2020). Other studies in
342 European countries have even found higher rates of diarrhoea, up to half of the patients
343 (Klopfenstein et al., 2020; Lechien et al., 2020).
344 A study exploring the clinical characteristics of COVID-19 patients without or with
345 gastrointestinal symptoms (nausea, vomiting or diarrhoea) suggests that the gastrointestinal

346   expression of symptoms is associated with some risk factors (family clustering in exposure, pre-
347   existing chronic liver disease) and with a more severe/critical type of the disease and higher rates
348   of body temperature >38.5°C (Jin et al., 2020). However, the association between diarrhoea and
349   a more severe disease has not been a well-replicated finding, and meta-analysis suggests that
350   there is no relationship between this gastrointestinal symptom and the severity of the COVID-19
351   disease (Henry et al., 2020). Another study points out that 19.4% of COVID-19 patients with
352   gastrointestinal symptoms experienced diarrhoea as their first symptom before the onset of
353   respiratory symptoms (Han et al., 2020).
354   SARS-CoV-2 protein interacts with human angiotensin-converting enzyme 2 (ACE2) molecules,
355   which are highly expressed in absorptive enterocytes from ileum and colon (Adhikari et al.,
356   2020; Zhang et al., 2020a). ACE2 is recognised as an important regulator of intestinal
357   inflammation, and it has been hypothesized this is the mechanism by which diarrhoea in
358   COVID-19 is caused (Ong, Young & Ong, 2020). The SARS-CoV-2 binding affinity for human
359   ACE2 is significantly stronger (10–20 times more) than its 2003 SARS-CoV predecessor
360   (D'Amico et al., 2020). Already in February, some authors suggested that faecal-oral
361   transmission of SARS-CoV-2 was possible (Yeo, Kaushal & Yeo, 2020), with later studies
362   confirming the presence of SARS-CoV-2 RNA in stool specimens of approximately 53-66% of
363   patients (Chen et al., 2020a; Xiao et al., 2020), independently of the presence of gastrointestinal
364   symptoms or the severity of illness (Chen et al., 2020a). There have been cases that although the
365   SARS-CoV-2 test was negative in the nasopharyngeal swab test after treatment, the rectal test
366   swabs specimens still tested positive (Wei et al., 2020), particularly in paediatric patients (Xu et
367   al., 2020a), suggesting that the rectal swab may be equally important to the pharyngeal swab (He
368   et al., 2020). Surveillance and adequate disinfection in latrines in areas with severe SARS-CoV-2
369   infection to avoid fomite transmission has been also recommended by some authors (He et al.,
370   2020), or even avoiding sharing toilets with family patients for those patients with COVID-19
371   when discharged to home (Li et al., 2020a). As upper gastrointestinal endoscopy can induce
372   coughing and lower gastrointestinal endoscopy can generate aerosol droplets as air is expelled
373   from patients, preparedness for personal protective equipment in the endoscopy setting has also
374   been recommended (Ong, Young & Ong, 2020; Wong, Lui & Sung, 2020).
375   Previous research has not detected viral RNA in urine specimens (Wang et al., 2020c). We did
376   not find studies reporting a direct effect of the SARS-CoV-2 on polyuria. However, it is
377   important to underscore that COVID-19 might induce diabetic ketoacidosis in those patients with
378   diabetes (Li et al., 2020c), which is a cause of polyuria.
379   Finally, no studies about toilet paper usage nor hoarding in patients with COVID-19 were found.
380
381   Social cognitive biases and social media as facilitators of the toilet paper hoarding (Mechanism
382   #2)
383   Social cognitive biases might contribute to the mimicking of conduct by other people. A
384   particularly pivotal role in socially replicated conduct is the bandwagon effect, which might be
385   defined as a phenomenon where the rate of uptake of beliefs, ideas, fads and trends increases the

386   more that they have already been adopted by others (O'Connor & Clark, 2019). This effect has
387   been applied in politics since the 19th century, coining the term 'jump on the bandwagon' when
388   a circus clown, Dan Rice, used a bandwagon for the political campaign of future-president
389   Zachary Taylor (Chappelow, 2019). This effect might be used to explain some conducts, such as
390   buying paper toilet rolls if everybody is buying them. In fact, toilet paper hoarding is a
391   phenomenon that has been proven to be sensitive to this bandwagon effect in other time periods.
392   For instance, in December 1973, in a time of shortages in the United States due to the OPEC oil
393   embargo, Johnny Carson made a joke during his opening monologue of The Tonight Show about
394   an upcoming toilet paper shortage and triggered a nationwide toilet paper buying spree (Malcom,
395   1974). It might also be that stress-related situations are involved (e.g., the oil crisis in 1973, the
396   COVID-19 pandemic in 2019-2020), as it is thought that stress potentiates decision biases along
397   with a shift from deliberative to intuitive thinking (Yu, 2016; Jacob et al., 2017). Information
398   bias during decision-making favours considering the benefits of saving and the costs of
399   discarding, which can lead to hoarding behaviour (Steketee & Frost, 2003).
400   People with acute stress disorder report more cognitive biases pertaining to external harm,
401   somatic sensations and social events (Smith & Bryant, 2000), suggesting that stress moderates
402   reasoning capability. Socially anxious people are more prone to interpret emotionally ambiguous
403   situations as threatening or negative, also known as interpretation bias, which is involved in the
404   maintenance of anxiety and stress reactivity (Badra et al., 2017; Van Bockstaele et al., 2019).
405   Some authors have suggested that people with elevated negative affectivity and social inhibition,
406   also known as type D personality (Denollet, 2005), might report higher perceived threat and
407   feeling of distress during ambiguous situations (Grynberg et al., 2012) and exhibit an increased
408   risk to stress-related cardiovascular events (Denollet et al., 2006). Studies suggest that
409   individuals with high social stress tend toward vigilance to subliminal social threat cues but not
410   subliminal physical threat cues (Helzer, Connor-Smith & Reed, 2009). A general negative
411   cognitive bias when coping with traumatic exposures is considered to be a risk factor for post-
412   traumatic stress disorder (DiGangi et al., 2013). Traumatic life experiences have also been
413   suggested to increase the psychosis proneness via cognitive biases (Gawęda et al., 2018) such as
414   jumping to conclusions ('not needing long to reach a conclusion'), belief inflexibility bias ('not
415   needing to consider alternatives when making a decision'), attention to threat bias ('people
416   cannot be trusted') and external attribution bias ('things go wrong because of other people').
417   Previous research exploring the response to social stress in a virtual reality environment suggest
418   that there is an additive effect of separate cognitive biases on paranoid response to social stress,
419   with greater effects by attention to threat bias and external attribution bias (Pot-Kolder et al.,
420   2018). Studies including patients with schizophrenia and acute delusions also indicate that
421   patients show an increased jumping to conclusion bias under stress (Moritz et al., 2015).
422   Risk communication, defined by the World Health Organization as "the exchange of real-time
423   information, advice and opinions between experts and people facing threats to their health,
424   economic or social well-being", might lead to hoarding behaviour (Abrams & Greenhawt, 2020).
425   This risk communication is more relevant in the last years, as social media networks are

426 constantly increasing. Another threat to human society is digital misinformation that has been
427 suggested to be related to the phenomenon called "echo chambers", which lead the diffusion
428 with a bandwagon effect (Törnberg, 2018). Another problem of misinformation is that false news
429 diffuses faster than true news in social networks (Vosoughi, Roy & Aral, 2018). The bandwagon
430 effect does not only apply to negative or threatening news. For instance, during the COVID-19
431 pandemic, the toilet paper challenge spread over the social media and was replicated by
432 thousands of people. This challenge, also known as the "10 Touch Challenge," was initially
433 proposed by football players who tried to juggle a roll of toilet paper ten times with their feet,
434 similarly to how soccer players juggle soccer balls in training (White, 2020). Thousands of
435 people uploaded their personal videos on the internet, which seemed to relieve the negative
436 effects of the lockdown because most people ended their videos with a satisfactory smile.
437 Although it is unknown how long this positive psychological effect lasts, this conduct is a clear
438 contribution of how the bandwagon effect contributed to an inadequate use of toilet paper during
439 the COVID-19 pandemic.
440
441 Stress worsens mental health and toilet paper hoarding (Mechanism #3)
442 Stress promotes the secretion of hormones (e.g. glucocorticoids, catecholamines) that are
443 adaptive in the short run but that might promote pathophysiological processes over longer time
444 periods, when they are secreted in excess or are dysregulated either by not being produced in
445 sufficient amounts during periods of challenge or change, or by not being shut off efficiently
446 after the challenge (McEwen, 2001). Bruce McEwen coined the term allostatic load to define
447 "the wear and tear on the body" as a result of the accumulation of chronic stress (McEwen,
448 1998). This model might be applied to most mental illnesses including mood disorders
449 (McEwen, 2003), psychotic disorders (Nugent et al., 2015) and anxiety disorders (Nolte et al.,
450 2011).
451 Stressful and traumatic life events might trigger the onset of hoarding disorder, particularly for
452 those cases with a later onset (Tolin et al., 2010; Landau et al., 2011). Stress, mainly changes in
453 relationships and interpersonal violence, are also associated with an exacerbation of hoarding
454 behaviour (Tolin et al., 2010). Other studies point out that early life stress with insecure
455 attachment (Danet & Secouet, 2018; Crone et al., 2019) or low parental emotional warmth
456 (Alonso et al., 2004) might play a role in the pathogenesis of hoarding behaviours. Traumatic life
457 events are associated with a greater severity of hoarding symptoms, particularly in the clutter
458 factor of compulsive hoarding (but not on the difficulty discarding or acquisitioning) (Cromer,
459 Schmidt & Murphy, 2007). It has been suggested that the coexistence of traumatic experiences
460 and inattention and hyperactivity symptoms could contribute to the difficulties to clutter and
461 organization reported by hoarders (Hartl et al., 2005). However, other experimental studies that
462 have tested whether stress influences saving and acquiring behavioural tendencies in young
463 adults (Shaw & Timpano, 2016) have yielded unexpected results: participants in the stress
464 condition saved and acquired fewer items than those in the control condition. As discussed by the
465 authors of the previous study (Shaw & Timpano, 2016), the laboratory stressor may not have

466   been strong enough to increase saving and acquiring behavioural tendencies, and there is a need
467   to conduct studies exploring the effects of acute stressors that are more similar to real-life
468   stressors experienced by individuals with hoarding (such as interpersonal conflict).
469   Intolerance to uncertainty has been proposed as a risk factor for hoarding behaviour (Wheaton et
470   al., 2016). Interestingly, recent studies exploring the role of intolerance to uncertainty in mental
471   well-being associated with the COVID-19 pandemic have reported that rumination and fear of
472   COVID-19, in combination, mediate the association between intolerance to uncertainty and
473   mental well-being (Satici et al., 2020). Many of the recommended measures during the COVID-
474   19 pandemic, such as washing and prevention of contamination as well as the quarantine and
475   nationwide lockdown, are thought to worsen symptoms of patients with OCD or hoarding
476   behaviours (Banerjee, 2020). Recent preliminary studies suggest that OCD patients worsened
477   their symptoms, particularly contamination obsessions, during the COVID-19 pandemic (Davide
478   et al., 2020).
479   Personality traits are also important moderators of the response to stressful situations,
480   particularly neuroticism, that appears to play a prominent role in the stress process (De Jong,
481   Van Sonderen & Emmelkamp, 1999). People with high neuroticism report more exposure to
482   stressors (Bolger & Schilling, 1991), higher perceived stress (Ebstrup et al., 2011; Kim et al.,
483   2016) and more inadequate coping strategies (Connor-Smith & Flachsbart, 2007). People with
484   high neuroticism are at greater risk for major depression and are more sensitive to the
485   depressogenic effects of adversity resulting from exposure to stressful life events (Kendler, Kuhn
486   & Prescott, 2004). Neuroticism has been also associated with hoarding obsessions and
487   compulsions in a study that assessed personality with the NEO-Personality-Inventory-Revised
488   (LaSalle-Ricci et al., 2006). In this later study, hoarding was negatively correlated with
489   conscientiousness.
490   Regarding the COVID-19 pandemic, there are two studies that have analysed the role of
491   personality traits in toilet paper stockpiling. The first study by Garbe et al. (Garbe, Rau & Toppe,
492   2020), already mentioned in the Results section of the systematic review, reported that
493   conscientiousness was associated with toilet paper stockpiling, although emotionality had an
494   indirect effect on stockpiling by means of the threat of COVID-19. Another unpublished study
495   by Columbus (Columbus) conducted a survey in two samples of UK residents and considered the
496   stockpiling of foods or supplies. Approximately 36% (sample 1) to 40% (sample 2) of
497   participants reported having bought more food or supplies than usually during the preceding two
498   weeks in response to the COVID-19 pandemic. Honesty-humility showed a negative association
499   with past stockpiling (sample 1) and a positive association with intentions to refrain from
500   stockpiling in the future (sample 2). The association between this personality dimension and
501   stockpiling was not mediated by beliefs about the shopping behaviour of others. However, other
502   studies suggest that viewing others experiencing stress creates a "contagious" physiological
503   stress response, with faster responses in people with high dispositional levels of empathy
504   (Dimitroff et al., 2017).

505   Some authors have made psychoanalytical explanations for the hoarding of toilet paper, such as a
506   form of regression to the anal stage allowing our Ego to feel in control of an incontrollable
507   situation (COVID-19 pandemic) (Anghelou, 2020; Wood, 2020). As suggested by Freud, the
508   second stage of psychosexual development is the anal stage (typically occurring during the 2nd
509   year of life), in which the child's interest and sexual pleasure are focused on the expulsion and
510   retention of faeces and the sadistic instinct is linked to the desire to both possess and destroy the
511   object (Association). Psychoanalytic theories suggest that a regression to the anal phase might
512   occur in people with hoarding disorder, particularly when something traumatic or emotionally
513   distressing happens (Camps & Bigot, 2019).
514
515   Cultural aspects moderate the relationship between the COVID-19 pandemic and toilet paper
516   hoarding (Mechanism #4)
517   Some studies have explored whether hoarding disorder features differ across distinct cultural
518   settings. A study that included patients with hoarding disorder from the United Kingdom, Spain,
519   Japan and Brazil (Nordsletten et al., 2018), indicates that the severity and core features of
520   hoarding disorder as well as the cognitions and behaviours commonly associated with this
521   condition, are largely stable across cultures. One study comparing symptoms from the hoarding
522   dimension in patients with OCD from China, USA and Brazil reported a lower proportion of
523   hoarding symptoms in the sample of patients from China (Li et al., 2009). However, another
524   study found that hoarding disorder in East Asia is relatively common and symptomatically
525   similar to that reported in western countries (Wang et al., 2016).
526   Other studies have explored potential cultural differences in cognitive biases. In a study that
527   examined the relationship between interpretation bias and social anxiety among Chinese
528   adolescents, the results were similar to those found in Western samples (Yu et al., 2019).
529   Although studies have not addressed whether there are differences in the social response to the
530   COVID-19 pandemic by distinct countries or cultures, an indirect way to approach this question
531   is to explore Google trend topics. In the Google trend topics by country for the word "toilet
532   paper", Australia was the leading country (score of 100), followed by USA (score of 74) and
533   Canada (score of 42). The trend in the use of the search term "toilet paper" on Google was
534   similar for these three countries and the United Kingdom (Figure 2, A-D), although a different
535   pattern was observed for India (Figure 2E), another country in which English is an official
536   language. As it can be seen in Figure 2, most countries had a peak in March 2020, which
537   coincides in time with COVID-19 outbreaks in different countries and the application of
538   lockdowns. The massive search of 'toilet paper' decreased in a few weeks to previous levels. If
539   we compare the Google search trends for 'toilet paper' and 'covid', in most countries the 'covid'
540   term was always above 'toilet paper' in search interest (Figure S1), with the exception of
541   Australia, such that in the first week of March, the interest for 'toilet paper' was 20, clearly
542   above the term 'covid' (interest of 5).
543   In a previous study that explored panic buying of toilet paper (Keane & Neal, 2020), an index of
544   panic during the COVID-19 pandemic was created considering five terms: toilet paper, panic

545   buying, hoarding, panic, supermarket. For non-English speaking countries, these terms were
546   translated. Countries were grouped into three regions (Europe and North America; Asia
547   [including Oceania]; and the rest of the world). Keane and Neal (Keane & Neal, 2020) found a
548   significant heterogeneity between regions in the timing and severity of the panic between
549   January and April 2020. They also compared the peak panic indexes between countries: Italy
550   (panic index of 0.15 on 22/3/2020, following the national lockdown on 20/3/2020); France
551   (panic index of 0.083 on 16/3/2020, the same day of the announcement of their nationwide
552   lockdown); United Kingdom (panic index of 0.18 on 22/3/2020, occurring in the same week of
553   the announcement of internal restrictions, including school closings and restrictions on
554   gatherings and movement); and Australia (panic index of 0.79 on 4/3/2020; it was the country
555   with the greatest speed of panic dissemination [as the panic index was 0.08 two days before, on
556   2/3/2020]). As there were no important policy announcements in Australia by this time
557   (restrictions on gatherings were announced on 13/3/2020), it is difficult to explain this massive
558   spike by these factors. The authors of the last study conclude that their model could not explain
559   this panic pattern in Australia. Other countries with massive spikes that could not be easily
560   explained were Japan, Taiwan and Singapore. The study of Keane and Neal suggests that internal
561   movement restrictions generate considerable consumer panic in the short run, but the effect
562   largely vanishes after a week to ten days. Moreover, they also found a response of consumer
563   panic to announcements of internal movement restrictions in foreign countries.
564   A cultural aspect that is important to take into account is the use of toilet paper by different
565   countries. Although there has been a global reduction in open defecation in the last two decades,
566   which might be defined as the lack of use of toilet facilities for defecation, there is still a
567   substantial worldwide proportion of people from rural areas in less economically developed
568   countries who use this defecating approach. For instance, data from the World Bank suggests
569   that the prevalence of open defecation in rural areas worldwide was 37.1% in 2000, with a
570   reduction up to 18.3% in 2017 ("People practicing open defecation, rural (% of rural
571   population)"). This information points to the possible differences in the use of toilet paper, and
572   likely hoarding conduct aiming to save this item, in rural areas when compared to urban areas, as
573   only 1.5% of the population of urban areas continues to use open defecation ("People practicing
574   open defecation, urban (% of urban population)").
575   Toilet paper consumption differs by countries. The estimated annual per capita toilet paper
576   consumption in selected countries in 2018 (obtained from Statista Consumer Market Outlook)
577   (Armstrong, 2020) describes USA as the leading country (141 rolls and 12.7 kg), followed by
578   Germany (134 rolls and 12.1 kg) and UK (127 rolls and 11.4 kg). There might also be
579   differences in cleaning habits between people from different countries. For instance, data from a
580   WIN/Gallup International survey conducted in 2015 suggests that only 50%of people in the
581   Netherlands wash their hands with soap and water after using the toilet compared to 96%of
582   people in Bosnia & Herzegovina (Marian).
583
584   **CATOTIM Algorithm for managing toilet paper hoarding**

585 An initial algorithm was revised by all authors. After subsequent revision that included 5
586 versions, a pilot proposal was suggested (Figure 3). A narrative synthesis of the algorithm will
587 also be included in the Discussion section, after the discussion of potential mechanisms linked to
588 toilet paper hoarding.
589

590 Discussion

591 Our study aimed to explore the potential contribution of the COVID-19 pandemic to toilet paper
592 hoarding. Our systematic review highlights the scarcity of studies addressing this important
593 topic, and we only identified few published data. We want to highlight the study by Garbe et al.
594 (Garbe, Rau & Toppe, 2020) that constituted a gem in the desert, as they added empirical data on
595 the influence of perceived threat of COVID-19 and personality traits (mainly conscientiousness)
596 on several behavioural aspects related to toilet paper shopping and stockpiling. Other studies
597 were focused on the hoarding of supplies (Columbus; Oosterhoff & Palmer, 2020) and they were
598 not specifically focused on toilet paper hoarding such as the study by Garbe et al. (Garbe, Rau &
599 Toppe, 2020). The secondary outcome of our systematic review focused on mental health, and
600 the inadequate use of toilet paper also underscores that this is an underresearched topic, as we
601 could only identify six case reports regarding OCD, suicide, homicide or pica, although the
602 quality of the case reports was relatively good. The methodology of a realist review allowed the
603 study of potential mechanisms contributing to the toilet paper hoarding in the COVID-19
604 pandemic.
605

606 Potential mechanisms relating the COVID19 pandemic to toilet paper hoarding
607 Although the authors of a systematic review on gastrointestinal symptoms in COVID-19 (Miri et
608 al., 2020) suggested that the coexistence of diarrhoea could explain the coronavirus panic buying
609 of toilet rolls, this hypothesis has not been adequately tested in the literature. Moreover, the
610 presence of diarrhoea or the prolonged dissemination of the SARS-CoV-2 in the faeces were less
611 known characteristics of the disease in the beginning of the outbreak, when people were buying
612 and hoarding toilet paper. Indeed, the knowledge that there might be a faecal-oral transmission of
613 the SARS-CoV-2 might induce some people to increase the use of toilet paper, but it does not
614 seem to be the main mechanism explaining the global shopping frenzy at supermarkets. The
615 relatively low proportion of diarrhoea (approximately 12-13%) found in people with the COVID-
616 19 infection does not seem to justify the global shopping of toilet paper. Moreover, the shopping
617 and hoarding of toilet paper appeared to be more intense in the first weeks following the
618 COVID-19 outbreak all around the world, with a reduction in the following weeks. This
619 generalized conduct in stores seems to mimic the Google trend surge on the internet for the word
620 "toilet paper" during March 2020 and was enhanced by national lockdowns by most but not all
621 (e.g., Australia) countries (Keane & Neal, 2020).
622 The mechanism linking social cognitive biases seems to contribute to the hoarding behaviour
623 more clearly than the gastrointestinal mechanism. The bandwagon effect is likely the most
624 replicated bias in different countries, as this effect has been previously found to be associated

625 with toilet paper buying (Malcom, 1974). The progressive increase in social networks seems to
626 have also contributed to the fast and worldwide expansion of toilet paper hoarding due to this
627 cognitive bias, replicating this behaviour in many countries. Other negative affect and
628 interpretation biases might be linked to the intolerance to uncertainty, a clinical characteristic
629 that has been associated with hoarding behaviour (Wheaton et al., 2016). These biases might be
630 even more important given the uncertainty of the COVID-19 situation (Koffman et al., 2020), as
631 the SARS-CoV-2 virus was a new virus with much information to be discovered. Interestingly,
632 the intolerance of uncertainty was associated with a poorer mental well-being mediated by both
633 the fear of COVID-19 and rumination (Satici et al., 2020).
634 Another question to be resolved is whether risk factors for toilet paper hoarding during the
635 COVID-19 pandemic are shared with other hoarding behaviours. In this sense, one study pointed
636 out that conscientiousness is a personality trait linked to toilet paper stockpiling during the
637 COVID-19 pandemic (Garbe, Rau & Toppe, 2020), whereas other studies including clinical
638 samples of patients with hoarding symptoms found an opposite result (lower conscientiousness
639 associated with hoarding symptoms) (LaSalle-Ricci et al., 2006). The different roles of
640 conscientiousness in patients with hoarding symptoms and healthy people who hoarded toilet
641 paper during the COVID-19 pandemic is an interesting finding that merits some discussion.
642 Conscientiousness is a personality trait that implies being more efficient and organized, showing
643 a self-discipline that involves planned behaviour (Costa, McCrae & Dye, 1991). This personality
644 trait fits well with the idea that healthy people under a stressful situation (e.g., COVID-19
645 pandemic) might decide to buy and hoard toilet paper, particularly when news point to the
646 possibility of a shortage of toilet paper (Schrotenboer, 2020). Although some studies have related
647 conscientiousness with OCD (Rector et al., 2002; Inchausti, Delgado & Prieto, 2015), other
648 studies have found lower conscientiousness in OCD patients when compared to healthy controls
649 (Hwang et al., 2012). Moreover, other studies suggest that there might exist differences based on
650 the OCD phenotype: higher conscientiousness in a comorbid tic-related OCD (Nestadt et al.,
651 2009), and lower conscientiousness in a comorbid affective-related class (Nestadt et al., 2009) or
652 with the presence of hoarding symptoms (LaSalle-Ricci et al., 2006; Samuels et al., 2008;
653 Boerema et al., 2019). The different associations between conscientiousness and hoarding
654 behaviour in non-clinical (higher conscientiousness) and clinical populations (low
655 conscientiousness) is an intriguing finding, as the non-clinical study included people recruited
656 during the COVID-19 pandemic (Garbe, Rau & Toppe, 2020), whereas the clinical studies
657 included patients with OCD (LaSalle-Ricci et al., 2006; Samuels et al., 2008; Boerema et al.,
658 2019). It is also possible that hoarding of toilet paper is a distinct phenotype compared with
659 hoarding other items, at least in terms of neurobiological/psychological pathophysiological
660 pathways. This important question is yet to be answered, as studies focused on toilet paper
661 hoarding are scarce. Future studies might examine whether personality traits linked to hoarding
662 differ upon the subtype of hoarded items. Although speculative, it could be that toilet paper
663 hoarding is a distinct subtype of hoarding disorder. To date, no definitive conclusions can be
664 drawn, and more research needs to address this issue before assuming a different subtype of the

665   hoarding disorder or even considering the inclusion of a specifier for toilet paper hoarding in
666   future diagnostic classifications (e.g., DSM-6). Another limitation of previous research on toilet
667   paper hoarding during the COVID-19 pandemic is that most of the data comes from surveys
668   without the administration of diagnostic interviews by a psychiatrist or a clinical psychologist.
669   Therefore, it is important to conduct clinical studies in the future to dissect the potential
670   boundaries between mental illnesses and non-psychiatric conditions in the research of toilet
671   paper hoarding. Although the diagnosis of a mental illness might require a dysfunction criteria,
672   the study of boundaries of psychiatric illnesses may not be solved until there is a detailed
673   understanding of the pathophysiology of the disorders (Kendell & Jablensky, 2003).
674   Future studies also need to better address potential cultural differences that could explain some
675   differences in toilet paper hoarding between countries. An intriguing question is why Australians
676   were the leaders in panic buying. Tim Neal, who participated in a study about panic buying
677   during the COVID-19 pandemic (Keane & Neal, 2020), pointed out that the Australian media's
678   coverage of hoarding could have contributed to the world-leading levels of panic (Zhou, 2020).
679   Other Asian countries, such as Japan, Taiwan and Singapore, that also had massive spikes that
680   could not be easily explained were with the model developed by Keane and Neal (Keane & Neal,
681   2020). Extravagant news from Asian countries were also reported early in the COVID pandemic,
682   including an armed robbery of toilet paper in Hong Kong (Ho-Him, 2020) or the chaining of
683   toilet papers in public toilets in Japan (Acharya, 2020). Some authors have suggested that dense,
684   close-knit networks of some countries (e.g., Singapore) make people more prone to believe their
685   contacts and take up mass behaviours (Bouffanais).
686
687   **Managing toilet paper hoarding: a proposed algorithm from the CATOTIM group**
688   The management of potential cases of toilet paper hoarding is a challenge for the clinician. The
689   differential diagnosis of a patient with hoarding symptoms is quite complex because hoarding
690   symptoms might be present in different psychiatric and neurological conditions (Pertusa et al.,
691   2010) and because patients with hoarding disorder often underreport specific symptoms
692   (DiMauro et al., 2013). Recent epidemiological studies indicate that the prevalence of hoarding
693   disorder in the general population is 2.5% (confidence interval: 1.7-3.6%), with similar
694   prevalence rates for both males and females (Postlethwaite, Kellett & Mataix-Cols, 2019). We
695   have tried to integrate the main findings of our review and the personal expertise of the members
696   of the CATOTIM group that participated in this study in a proposed algorithm that is described
697   in Figure 3.
698   As can be seen in Figure 3, the first key question is to know whether there is an accumulation
699   (hoarding) of toilet paper. For those cases with evident toilet paper hoarding, psychopathological
700   assessment needs to first detect potential confusional or cognitive problems (attention deficits,
701   memory loss). In that case, it is important to discard neurological syndromes such as dementias
702   that have been reported to be associated with hoarding symptoms in approximately 23-29% of
703   cases (Hwang et al., 1998; Mitchell et al., 2019). Patients suffering from delirium might have
704   complex stereotyped movements and rarely, the mimicking of a work pattern (occupational

705   delirium) (Burns, Gallagley & Byrne, 2004). In these situations, it is important to discard
706   intercurrent medical processes and it might be necessary to perform blood and urine tests, CT or
707   MRI brain scans, substance use studies, and/or cerebrospinal fluid analyses (in those cases with
708   fever). In those patients accumulating toilet paper who show amnesia of the situation and
709   alterations in personal identity, dissociative disorders including post-traumatic stress disorder
710   need to be considered. For this reason, inquiry about potential toilet-related traumatic events may
711   shed light on this diagnosis. In oriented patients, the presence of specific symptoms might lead to
712   specific diagnoses: auditory hallucinations in patients with schizophrenia or schizoaffective
713   disorders and specific delusions in patients with non-affective (e.g., schizophrenia) or affective
714   (bipolar disorder, psychotic depression) psychoses. For instance, a patient suffering from major
715   depression with psychotic features might hoard paper if there are nihilistic or catastrophic
716   delusional ideas (e.g., the belief that bad things are about to happen, feelings of being rotten)
717   (Rothschild, 2013).
718   In some cases, it is possible that people hoard paper for giving it to others. In those cases when
719   there is a long-standing need for the person to be taken care of and a fear of being abandoned or
720   separated from close individuals, a dependent personality disorder needs to be considered.
721   People with bipolar disorder with hypomanic symptoms might also hoard paper for making gifts
722   to others, although the presence of a euphoric mood could also guide the diagnosis.
723   A particular important condition to be considered is OCD. Initially, hoarding symptoms were
724   thought to be a feature of OCD, but in the last DSM-5, a distinct entity for compulsive hoarding
725   was included. It is critical to explore other obsessive-compulsive symptoms (cleaning obsessions
726   and washing compulsions, sexual/religious obsessions, aggressive obsessions with checking
727   compulsions, symmetry obsessions with ordering compulsions) because their existence can guide
728   the diagnosis to an OCD when compared with a primary hoarding disorder without obsessive-
729   compulsive symptoms (Pertusa et al., 2008). It is important to underscore that hoarding
730   symptoms might be present in people with high neuroticism, particularly if they suffer from
731   generalized anxiety disorder (Tolin et al., 2011) or obsessive-compulsive personality disorder
732   (OCPD) (Mataix-Cols et al., 2010). If hoarding symptoms appear in people with social isolation
733   and restricted interests, autism disorders and specific personality disorders (schizoid
734   [indifference to social relationships, with a limited range of emotional expression and
735   experience] and avoidant [feelings of extreme social inhibition, inadequacy, and sensitivity to
736   negative criticism and rejection]) also need to be considered. In autism, hoarding symptoms are
737   common (approximately 25% of cases) and are associated with internalizing and
738   anxiety/depressive symptoms, externalizing behaviour, and attention problems (Storch et al.,
739   2016).
740   In those cases in which people have been hoarding for reselling toilet paper, antisocial
741   personality traits could be driving the hoarding conduct. There have been documented cases of
742   people hoarding up to 4800 toilet paper rolls for reselling them on eBay at a greater cost
743   ("Supermarket boss's blunt reply to toilet paper hoarder wanting refund," 2020). This conduct
744   during a pandemic shows some of the characteristics of an antisocial personality disorder (Black,

745 2015): disregard for right or wrong, deceit for exploitation of others, being disrespectful of
746 others, and lack of empathy for others.
747 If pathological conditions are not clearly found, as already mentioned, it is important to consider
748 the contribution of social cognitive biases (e.g., bandwagon effect) for inducing hoarding
749 symptoms in non-clinical populations.
750 Sometimes there is an excessive buying of toilet paper secondary to an excessive use without
751 hoarding behaviour. Clinicians need to consider in these cases the potential medical causes for
752 either diarrhoea or polyuria, with specific tests depending upon the reported symptoms. As
753 already mentioned, in rare conditions, people might eat toilet paper secondary to pica (Chisholm
754 & Martin, 1981; Fisher et al., 2014). In cases with pica, if hypozincaemia is observed,
755 supplementation with zinc might resolve the altered eating behaviour (Chisholm & Martin,
756 1981). An excessive (pathological) use of toilet paper by OCD patients with contamination
757 obsessions symptoms needs to be considered. In some cases with resistant OCD and excessive
758 wiping, tACS might be useful (Klimke et al., 2016). People with impulsive-control disorders and
759 borderline personality disorder might also use toilet paper in excess due to a lack of inhibition
760 control.
761 Although in some cases there is no apparent hoarding or excessive use of toilet paper, it is
762 important to consider pathological use of toilet paper due to psychopathological disturbances. In
763 people with bipolar disorder with a manic episode, spending sprees and bizarre gifts might occur.
764 In other cases, it is possible that there is a surreptitious hoarding that was not easily observed in
765 the first assessment. This could be the case in people with psychotic symptoms, particularly if
766 there is suspiciousness (e.g., paranoid personality disorder, psychotic disorders). In a patient with
767 depressive mood, suicide ideas need to be explored because toilet paper might be used as a lethal
768 mechanism for committing suicide (Sauvageau & Yesovitch, 2006; Saint-Martin, Bouyssy &
769 O'Byrne, 2007).
770 If there is no apparent psychopathology, the diagnosis might be reconsidered. However, a
771 previous step is to be sure that the individual has not participated in the toilet paper challenge. If
772 this is the case, it is probable that his/her conduct is driven by social cognitive biases (e.g.,
773 bandwagon effect).
774
775 **Clinical and ecological implications**
776 Our study underscores the need to consider inadequate use and hoarding of toilet paper in the
777 clinical practice, as this conduct might have negative consequences on the functioning and
778 quality of life of people with or without serious mental illnesses. It is particularly important to
779 discard psychiatric disorders that might be associated with toilet paper hoarding and that might
780 require specific treatments. This approach is a challenge for the psychiatrist and clinical
781 psychologist who need to consider potential comorbid medical conditions that could also worsen
782 this conduct.
783 The potential contribution of social media to social cognitive biases (e.g., bandwagon effect) and
784 social-driven panic behaviours underscores the importance of managing news in the media and

785   to avoid disseminating fake news on the internet. To fight this issue, in April 2018, the European
786   Commission and representatives of online platforms, leading social networks, advertisers and the
787   advertising industry agreed on a self-regulatory Code of Practice to address the spread of online
788   disinformation and fake news (Commission). Attached to the principles of this Code of Practice
789   is a step to be done by most people using and working with social media in order to avoid the
790   negative psychological consequences of disseminating fake news.
791   Recent updated analysis from the Natural Resources Defense Council (NRDC) ("Toilet Paper
792   and Climate Change: NRDC's Updated 'Issue With Tissue' Ranks Brands on Sustainability,"
793   2020) has reported the climate impacts caused by the "tree to toilet" pipeline destroying the
794   climate-critical Canadian boreal forest. It is thought that industry clear-cuts one million acres of
795   boreal forest each year (led by Brazil, Russia and Canada in terms of global intact forest loss) in
796   part to produce pulp that US tissue makers roll into toilet paper ("Toilet Paper and Climate
797   Change: NRDC's Updated 'Issue With Tissue' Ranks Brands on Sustainability," 2020).
798   Environmentalists denounce that turning a tree to paper requires more water than turning paper
799   back into fibre, and many brands using tree pulp also use polluting chlorine-based bleach for
800   obtaining greater whiteness (Kaufman, 2009). Another problem for the sustainability of the
801   planet is the continuously growing tendency of toilet paper ("Toilet paper is getting less
802   sustainable, researchers warn," 2019). The worldwide revenue of the segment of toilet paper
803   from the tissue and hygiene paper sector in 2018 was US$ 81 billion, and it is expected that will
804   increase up to US$ 94 billion by the year 2023 ("Tissue and Hygiene Paper Report 2019 - Toilet
805   Paper," 2019). A report by the NRDC (Skene, 2019) suggests that as the market for tissue grows
806   around the world, recycled products and alternative fibres will be the only way to accommodate
807   increased demand without creating further strain on indigenous peoples, the climate, and
808   biodiversity.
809   For all these reasons, it is important that policy makers consider the potential negative impact of
810   toilet paper hoarding not only at the individual level but also at a community level, with potential
811   harmful effects to the planet. Therefore, it would be recommended that policy makers develop
812   strategies that promote the research of the causes and consequences of toilet paper hoarding.
813
814   **Gaps in the literature and future directions**
815   Although a previous survey (Garbe, Rau & Toppe, 2020) suggested that the prevalence for toilet
816   paper hoarding was 17.2% for North Americans and 13.7% for Europeans, more epidemiological
817   studies are needed for weighting the real prevalence of this hoarding behaviour and to administer
818   diagnostic interviews for discarding hoarding conducts associated with psychiatric disorders or
819   stress-related 'reactive' and 'transitional' conduct. Longitudinal studies could also help to
820   explore whether these hoarding behaviours associated with the COVID-19 pandemic were only
821   associated with the first COVID-19 outbreak or are repeated in subsequent outbreaks.
822   The psychological and neurobiological underpinnings of toilet paper hoarding are a fascinating
823   field to be explored. Future research might study whether the mechanisms that lead to saving
824   toilet paper are shared or not with other hoarded items. A particularly interesting hypothesis to be

825   tested relies on the contribution of personality traits, given the apparent different role of
826   conscientiousness on toilet paper hoarding during the COVID-19 pandemic (Garbe, Rau &
827   Toppe, 2020) and on hoarding symptoms in people with OCD (LaSalle-Ricci et al., 2006; J.F. et
828   al., 2008). Neurobiological determinants might study the contribution of stress-related
829   biomarkers including hypothalamic-pituitary-adrenal (HPA) axis hormones and cytokines, given
830   the implication of these biomarkers in stress-related pathologies (Soria et al., 2018; Russell &
831   Lightman, 2019). Future studies might want to address the study of faeces, as the gut microbiota
832   has emerged as a key player in the control of the HPA axis, especially during stressful situations
833   caused by real or perceived homeostatic challenge (Foster, Rinaman & Cryan, 2017).
834   Neuroimaging studies might also explore the neural correlates of toilet paper hoarding. Patients
835   with hoarding disorder show higher dorsolateral prefrontal cortex (DLPFC) activation during
836   tests of executive functions than do patients with OCD (Hough et al., 2016). OCD patients with
837   prominent hoarding symptoms have also shown greater activation in the bilateral anterior
838   ventromedial prefrontal cortex (VMPFC) than do patients without hoarding symptoms and
839   healthy controls (An et al., 2009). As previous studies have shown dramatic improvement in
840   anus wiping of an OCD patient after brain stimulation with tACS targeting the DLPFC, future
841   studies might study the role of the prefrontal cortex on the pathogenesis of toilet paper hoarding.
842
843   **Study limitations**
844   The main limitation of our study is the small number of studies included in our systematic
845   review. A meta-analysis could not be performed for this reason, as in the protocol of our
846   systematic review, we aimed to include a minimum of 5 studies with similar effect sizes for
847   conducting a quantitative meta-analytical synthesis. We increased the number of publications
848   with the realist review, and we also included grey literature, but the evidence generated from
849   studies during the COVID-19 pandemic was particularly low. It is also possible that there is a
850   negative publication bias on toilet paper hoarding, as authors might avoid publishing articles
851   dealing with toilet paper. In this line, negative outcomes associated with inadequate use of toilet
852   paper (e.g., suicide cases secondary to toilet paper choking) might also be considered humiliating
853   and being underreported in the scientific literature.
854   Finally, although we have proposed an algorithm for managing toilet paper hoarding or other
855   inadequate uses of toilet paper, it is important to underscore that this algorithm has not been
856   validated. Future studies might improve this limitation by testing and validating its application in
857   clinical practice. If our algorithm is validated in future studies, it might be useful for psychiatrists
858   and clinical psychologists that need to manage people with potential toilet paper hoarding
859   behaviours.
860   Although our study has several limitations, it is also the first realist review exploring potential
861   mechanisms that could explain in part the toilet paper hoarding experienced in many countries
862   during the COVID-19 pandemic. Our study allows the identification of gaps in the literature and
863   will help researchers to design and conduct future studies aiming to better understand the causes

864 and consequences of toilet paper hoarding in the general population and in people suffering from
865 mental illnesses.
866

Conclusions

868 The COVID-19 pandemic has been associated with a worldwide increase of hoarding
869 behaviours, with toilet paper being one of the most desired objects. Social media and social
870 cognitive biases seem be major contributors to this hoarding behaviour and might explain some
871 differences in toilet paper hoarding between countries. Other mental health-related factors are
872 likely to be involved, such as the stressful situation of the COVID-19 pandemic and fear of
873 contagion or particular personality traits (conscientiousness). Future studies might help to better
874 characterize the phenotype of toilet paper hoarding and to explore psychological and
875 neurobiological mechanisms underlying this behaviour.
876

Acknowledgements

878 This review is a proposal of the Catalan Toilet Tissue Research Group in Mental Health
879 (CATOTIM) that is composed of psychiatrists and clinical psychologists interested in the study
880 of the causes and consequences of inadequate toilet paper use. All authors are members of the
881 CATOTIM group. As people were hoarding toilet paper amid the coronavirus pandemic, this
882 study was driven by the interest of studying potential mechanisms linked to this behaviour that
883 can cause distress to the individual.

884

References

886 Abrams EM, Greenhawt M. 2020. Risk Communication During COVID-19. Journal of Allergy
887 and Clinical Immunology: In Practice. DOI: 10.1016/j.jaip.2020.04.012.
888 Acharya D. 2020.Amid The Coronavirus Outbreak, Public Toilets Chain Toilet Paper Rolls
889 Because People Are Stealing Them Like Crazy. Available at
890 https://mobygeek.com/features/japan-toilets-chian-toilet-paper-rolls-to-avoid-thieves-12251
891 Adhikari SP, Meng S, Wu YJ, Mao YP, Ye RX, Wang QZ, Sun C, Sylvia S, Rozelle S, Raat H,
892 Zhou H. 2020. Epidemiology, causes, clinical manifestation and diagnosis, prevention and
893 control of coronavirus disease (COVID-19) during the early outbreak period: A scoping review.
894 Infectious Diseases of Poverty. DOI: 10.1186/s40249-020-00646-x.
895 Alonso P, M. Menchón J, Mataix-Cols D, Pifarré J, Urretavizcaya M, Crespo JM, Jiménez S,
896 Vallejo G, Vallejo J. 2004. Perceived parental rearing style in obsessive-compulsive disorder:
897 Relation to symptom dimensions. Psychiatry Research. DOI: 10.1016/j.psychres.2001.12.002.
898 An SK, Mataix-Cols D, Lawrence NS, Wooderson S, Giampietro V, Speckens A, Brammer MJ,
899 Phillips ML. 2009. To discard or not to discard: The neural basis of hoarding symptoms in
900 obsessive-compulsive disorder. Molecular Psychiatry. DOI: 10.1038/sj.mp.4002129.

901 Anghelou A. 2020.Why everyone is buying toilet paper and how you can manage this period of
902 isolation due to Coronavirus. Available at https://www.neweurope.eu/article/why-is-everyone-
903 buying-toilet-paper-and-how-can-you-manage-this-period-of-isolation-due-to-the-coronavirus/
904 Armstrong M. 2020.The U.S. Leads the World in Toilet Paper Consumption. Available at
905 https://www.statista.com/chart/15676/cmo-toilet-paper-consumption/
906 Association AP.Anal stage. Available at https://dictionary.apa.org/anal-stage
907 Badra M, Schulze L, Becker ES, Vrijsen JN, Renneberg B, Zetsche U. 2017. The association
908 between ruminative thinking and negative interpretation bias in social anxiety. Cognition and
909 Emotion. DOI: 10.1080/02699931.2016.1193477.
910 Banerjee DD. 2020. The other side of COVID-19: Impact on obsessive compulsive disorder
911 (OCD) and hoarding. Psychiatry Research. DOI: 10.1016/j.psychres.2020.112966.
912 Black DW. 2015. The natural history of antisocial personality disorder. Canadian Journal of
913 Psychiatry. DOI: 10.1177/070674371506000703.
914 Van Bockstaele B, Notebaert L, Salemink E, Clarke PJF, MacLeod C, Wiers RW, Bögels SM.
915 2019. Effects of interpretation bias modification on unregulated and regulated emotional
916 reactivity. Journal of Behavior Therapy and Experimental Psychiatry. DOI:
917 10.1016/j.jbtep.2019.03.009.
918 Boerema YE, de Boer MM, van Balkom AJLM, Eikelenboom M, Visser HA, van Oppen P.
919 2019. Obsessive compulsive disorder with and without hoarding symptoms: Characterizing
920 differences. Journal of Affective Disorders. DOI: 10.1016/j.jad.2018.12.115.
921 Bolger N, Schilling EA. 1991. Personality and the Problems of Everyday Life: The Role of
922 Neuroticism In Exposure and Reactivity to Daily Stressors. Journal of Personality. DOI:
923 10.1111/j.1467-6494.1991.tb00253.x.
924 Bouffanais R.Hoarding toilet paper: The mystery of such panic buying explained. Available at
925 https://www.linkedin.com/pulse/hoarding-toilet-paper-mystery-panic-buying-explained-
926 bouffanais?trk=portfolio_article-card_title
927 Buchholz K. 2020.Toilet Paper Producers Roll'ing in the Dough. Available at
928 https://www.statista.com/chart/21327/rise-in-revenue-toilet-paper-selected-countries/
929 Bulli F, Melli G, Carraresi C, Stopani E, Pertusa A, Frost RO. 2014. Hoarding behaviour in an
930 Italian non-clinical sample. Behavioural and Cognitive Psychotherapy. DOI:
931 10.1017/S1352465812001105.
932 Burns A, Gallagley A, Byrne J. 2004. Delirium. Journal of Neurology, Neurosurgery and
933 Psychiatry. DOI: 10.1136/jnnp.2003.023366.
934 Camps FD, Bigot J Le. 2019. A psychoanalytical approach to diogenes syndrome.
935 Psychoanalytic Review. DOI: 10.1521/prev.2019.106.3.207.
936 Chappelow J. 2019.Bandwagon effect. Available at
937 https://www.investopedia.com/terms/b/bandwagon-effect.asp
938 Chen Y, Chen L, Deng Q, Zhang G, Wu K, Ni L, Yang Y, Liu B, Wang W, Wei C, Yang J, Ye
939 G, Cheng Z. 2020a. The Presence of SARS-CoV-2 RNA in Feces of COVID-19 Patients. Journal
940 of medical virology. DOI: 10.1002/jmv.25825.

941 Chen Q, Zheng Z, Zhang C, Zhang X, Wu H, Wang J, Wang S, Zheng C. 2020b. Clinical
942 characteristics of 145 patients with corona virus disease 2019 (COVID-19) in Taizhou, Zhejiang,
943 China. Infection. DOI: 10.1007/s15010-020-01432-5.
944 Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T,
945 Zhang X, Zhang L. 2020c. Epidemiological and clinical characteristics of 99 cases of 2019 novel
946 coronavirus pneumonia in Wuhan, China: a descriptive study. The Lancet. DOI: 10.1016/S0140-
947 6736(20)30211-7.
948 Cheung KS, Hung IFN, Chan PPY, Lung KC, Tso E, Liu R, Ng YY, Chu MY, Chung TWH,
949 Tam AR, Yip CCY, Leung K-H, Fung AY-F, Zhang RR, Lin Y, Cheng HM, Zhang AJX, To
950 KKW, Chan K-H, Yuen K-Y, Leung WK. 2020. Gastrointestinal Manifestations of SARS-CoV-
951 2 Infection and Virus Load in Fecal Samples From a Hong Kong Cohort: Systematic Review and
952 Meta-analysis. Gastroenterology. DOI: 10.1053/j.gastro.2020.03.065.
953 Chisholm JC, Martin HI. 1981. Hypozincemia, ageusia, dysosmia, and toilet tissue pica. Journal
954 of the National Medical Association.
955 Columbus S. Who Hoards? Honesty-Humility and Behavioural Responses to the 2019/20
956 Coronavirus Pandemic. PsyArXiv Preprints. DOI: 10.31234/osf.io/8e62v.
957 Commission E.Code of Practice on Disinformation. Available at https://ec.europa.eu/digital-
958 single-market/en/news/code-practice-disinformation
959 Connor-Smith JK, Flachsbart C. 2007. Relations Between Personality and Coping: A Meta-
960 Analysis. Journal of Personality and Social Psychology. DOI: 10.1037/0022-3514.93.6.1080.
961 Coronavirus: Armed robbers steal hundreds of toilet rolls in Hong Kong. 2020. Available at
962 https://www.bbc.com/news/world-asia-china-51527043
963 Costa PT, McCrae RR, Dye DA. 1991. Facet scales for agreeableness and conscientiousness: A
964 revision of tshe NEO personality inventory. Personality and Individual Differences. DOI:
965 10.1016/0191-8869(91)90177-D.
966 COVID-19 Coronavirus Pandemic. Available at https://www.worldometers.info/coronavirus/
967 Cromer KR, Schmidt NB, Murphy DL. 2007. Do traumatic events influence the clinical
968 expression of compulsive hoarding? Behaviour Research and Therapy. DOI:
969 10.1016/j.brat.2007.06.005.
970 Crone C, Kwok C, Chau V, Norberg MM. 2019. Applying attachment theory to indecisiveness in
971 hoarding disorder. Psychiatry Research. DOI: 10.1016/j.psychres.2019.01.055.
972 D'Amico F, Baumgart DC, Danese S, Peyrin-Biroulet L. 2020. Diarrhea During COVID-19
973 Infection: Pathogenesis, Epidemiology, Prevention, and Management. Clinical Gastroenterology
974 and Hepatology. DOI: 10.1016/j.cgh.2020.04.001.
975 Da Z, Engelberg J, Gao P. 2011. In Search of Attention. Journal of Finance. DOI:
976 10.1111/j.1540-6261.2011.01679.x.
977 Danet M, Secouet D. 2018. Insecure attachment as a factor in hoarding behaviors in a non-
978 clinical sample of women. Psychiatry Research. DOI: 10.1016/j.psychres.2018.09.053.
979 Davide P, Andrea P, Martina O, Andrea E, Davide D, Mario A. 2020. The impact of the COVID-
980 19 pandemic on patients with OCD: Effects of contamination symptoms and remission state

981   before the quarantine in a preliminary naturalistic study. Psychiatry Research. DOI:
982   10.1016/j.psychres.2020.113213.
983   Denollet J. 2005. DS14: Standard assessment of negative affectivity, social inhibition, and type
984   D personality. Psychosomatic Medicine. DOI: 10.1097/01.psy.0000149256.81953.49.
985   Denollet J, Pedersen SS, Vrints CJ, Conraads VM. 2006. Usefulness of type D personality in
986   predicting five-year cardiac events above and beyond concurrent symptoms of stress in patients
987   with coronary heart disease. American Journal of Cardiology. DOI:
988   10.1016/j.amjcard.2005.10.035.
989   DiGangi JA, Gomez D, Mendoza L, Jason LA, Keys CB, Koenen KC. 2013. Pretrauma risk
990   factors for posttraumatic stress disorder: A systematic review of the literature. Clinical
991   Psychology Review. DOI: 10.1016/j.cpr.2013.05.002.
992   DiMauro J, Tolin DF, Frost RO, Steketee G. 2013. Do people with hoarding disorder under-
993   report their symptoms? Journal of Obsessive-Compulsive and Related Disorders. DOI:
994   10.1016/j.jocrd.2013.01.002.
995   Dimitroff SJ, Kardan O, Necka EA, Decety J, Berman MG, Norman GJ. 2017. Physiological
996   dynamics of stress contagion. Scientific Reports. DOI: 10.1038/s41598-017-05811-1.
997   van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, Tamin
998   A, Harcourt JL, Thornburg NJ, Gerber SI, Lloyd-Smith JO, de Wit E, Munster VJ. 2020. Aerosol
999   and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. The New England
1000   journal of medicine. DOI: 10.1056/NEJMc2004973.
1001   Ebstrup JF, Eplov LF, Pisinger C, Jørgensen T. 2011. Association between the five factor
1002   personality traits and perceived stress: Is the effect mediated by general self-efficacy? Anxiety,
1003   Stress and Coping. DOI: 10.1080/10615806.2010.540012.
1004   Fisher C, Laudenslager M, Thapar M, Rothstein K. 2014. A Case of Gastritis in a Patient With
1005   Paper Pica. American Journal of Gastroenterology. DOI: 10.14309/00000434-201410002-00922.
1006   Foster JA, Rinaman L, Cryan JF. 2017. Stress & the gut-brain axis: Regulation by the
1007   microbiome. Neurobiology of Stress. DOI: 10.1016/j.ynstr.2017.03.001.
1008   Garbe L, Rau R, Toppe T. 2020. Influence of perceived threat of Covid-19 and HEXACO
1009   personality traits on toilet paper stockpiling. PLOS ONE. DOI: 10.1371/journal.pone.0234232.
1010   Gawęda Ł, Prochwicz K, Adamczyk P, Frydecka D, Misiak B, Kotowicz K, Szczepanowski R,
1011   Florkowski M, Nelson B. 2018. The role of self-disturbances and cognitive biases in the
1012   relationship between traumatic life events and psychosis proneness in a non-clinical sample.
1013   Schizophrenia Research. DOI: 10.1016/j.schres.2017.07.023.
1014   Goel S, Hofman JM, Lahaie S, Pennock DM, Watts DJ. 2010. Predicting consumer behavior
1015   with web search. Proceedings of the National Academy of Sciences of the United States of
1016   America. DOI: 10.1073/pnas.1005962107.
1017   Greenhalgh T, Schmid MB, Czypionka T, Bassler D, Gruer L. 2020. Face masks for the public
1018   during the covid-19 crisis. The BMJ. DOI: 10.1136/bmj.m1435.

1019 Grynberg D, Gidron Y, Denollet J, Luminet O. 2012. Evidence for a cognitive bias of
1020 interpretation toward threat in individuals with a Type D personality. Journal of Behavioral
1021 Medicine. DOI: 10.1007/s10865-011-9351-7.
1022 Guan W, Ni Z, Hu Y, Liang W, Ou C, He J, Liu L, Shan H, Lei C, Hui DSC, Du B, Li L, Zeng
1023 G, Yuen KY, Chen R, Tang C, Wang T, Chen P, Xiang J, Li S, Wang JL, Liang Z, Peng Y, Wei
1024 L, Liu Y, Hu YH, Peng P, Wang JM, Liu J, Chen Z, Li G, Zheng Z, Qiu S, Luo J, Ye C, Zhu S,
1025 Zhong N. 2020. Clinical characteristics of coronavirus disease 2019 in China. New England
1026 Journal of Medicine. DOI: 10.1056/NEJMoa2002032.
1027 Han C, Duan C, Zhang S, Spiegel B, Shi H, Wang W, Zhang L, Lin R, Liu J, Ding Z, Hou X.
1028 2020. Digestive Symptoms in COVID-19 Patients With Mild Disease Severity: Clinical
1029 Presentation, Stool Viral RNA Testing, and Outcomes. The American journal of
1030 gastroenterology. DOI: 10.14309/ajg.0000000000000664.
1031 Hartl TL, Duffany SR, Allen GJ, Steketee G, Frost RO. 2005. Relationships among compulsive
1032 hoarding, trauma, and attention-deficit/ hyperactivity disorder. Behaviour Research and Therapy.
1033 DOI: 10.1016/j.brat.2004.02.002.
1034 He Y, Wang Z, Li F, Shi Y. 2020. Public health might be endangered by possible prolonged
1035 discharge of SARS-CoV-2 in stool. Journal of Infection. DOI: 10.1016/j.jinf.2020.02.031.
1036 Helzer EG, Connor-Smith JK, Reed MA. 2009. Traits, states, and attentional gates:
1037 Temperament and threat relevance as predictors of attentional bias to social threat. Anxiety,
1038 Stress and Coping. DOI: 10.1080/10615800802272244.
1039 Henry BM, de Oliveira MHS, Benoit J, Lippi G. 2020. Gastrointestinal symptoms associated
1040 with severity of coronavirus disease 2019 (COVID-19): a pooled analysis. Internal and
1041 Emergency Medicine. DOI: 10.1007/s11739-020-02329-9.
1042 Ho-Him C. 2020.Two arrested after armed gang makes run for toilet rolls in HK$1,600 heist as
1043 coronavirus panic shows no signs of easing. Available at https://www.scmp.com/news/hong-
1044 kong/law-and-crime/article/3050907/armed-gang-steals-hk1000-toilet-paper-coronavirus
1045 Hough CM, Luks TL, Lai K, Vigil O, Guillory S, Nongpiur A, Fekri SM, Kupferman E,
1046 Mathalon DH, Mathews CA. 2016. Comparison of brain activation patterns during executive
1047 function tasks in hoarding disorder and non-hoarding OCD. Psychiatry Research -
1048 Neuroimaging. DOI: 10.1016/j.pscychresns.2016.07.007.
1049 Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T,
1050 Xia J, Wei Y, Wu W, Xie X, Yin W, Li H, Liu M, Xiao Y, Gao H, Guo L, Xie J, Wang G, Jiang
1051 R, Gao Z, Jin Q, Wang J, Cao B. 2020. Clinical features of patients infected with 2019 novel
1052 coronavirus in Wuhan, China. The Lancet. DOI: 10.1016/S0140-6736(20)30183-5.
1053 Hwang JY, Shin YC, Lim SW, Park HY, Shin NY, Jang JH, Park HY, Kwon JS. 2012.
1054 Multidimensional Comparison of Personality Characteristics of the Big Five Model,
1055 Impulsiveness, and Affect in Pathological Gambling and Obsessive-Compulsive Disorder.
1056 Journal of Gambling Studies. DOI: 10.1007/s10899-011-9269-6.

1057 Hwang JP, Tsai SJ, Yang CH, Liu KM, Lirng JF. 1998. Hoarding behavior in dementia: A
1058 preliminary report. American Journal of Geriatric Psychiatry. DOI: 10.1097/00019442-
1059 199800640-00003.
1060 In Japan, toilet rolls are being chained to their dispensers. 2020. The Weekend Australian.
1061 Inchausti F, Delgado AR, Prieto G. 2015. Obsessive-compulsive disorder and its relationship
1062 with disgust vulnerability and conscientiousness. Psicothema. DOI: 10.7334/psicothema2015.7.
1063 J.F. S, O.J. B, A. P, D.L. M, J. P, S.L. R, A.J. F, M.A. G, B.D. G, J.A. K, J.T. M, B. C, M.A. R,
1064 S.A. R, D.L. P, K.-Y. L, R. H-S, A.E. P, G. N. 2008. Sex-specific clinical correlates of hoarding
1065 in obsessive-compulsive disorder. Behaviour Research and Therapy.
1066 Jacob C, Hoffmann V, Olliges E, Haile A, Jacobi B, Steinkopf L, Lanz M, Tschoep M, Meissner
1067 K. 2017. Stress changes how we think – Psychophysiological evidence for the Stress-Induced
1068 Deliberation to Intuition (SIDI)-model. Psychoneuroendocrinology. DOI:
1069 10.1016/j.psyneuen.2017.07.273.
1070 Jin X, Lian JS, Hu JH, Gao J, Zheng L, Zhang YM, Hao SR, Jia HY, Cai H, Zhang XL, Yu GD,
1071 Xu KJ, Wang XY, Gu JQ, Zhang SY, Ye CY, Jin CL, Lu YF, Yu X, Yu XP, Huang JR, Xu KL,
1072 Ni Q, Yu CB, Zhu B, Li YT, Liu J, Zhao H, Zhang X, Yu L, Guo YZ, Su JW, Tao JJ, Lang GJ,
1073 Wu XX, Wu WR, Qv TT, Xiang DR, Yi P, Shi D, Chen Y, Ren Y, Qiu YQ, Li LJ, Sheng J,
1074 Yang Y. 2020. Epidemiological, clinical and virological characteristics of 74 cases of
1075 coronavirus-infected disease 2019 (COVID-19) with gastrointestinal symptoms. Gut. DOI:
1076 10.1136/gutjnl-2020-320926.
1077 De Jong GM, Van Sonderen E, Emmelkamp PMG. 1999. A comprehensive model of stress. The
1078 roles of experienced stress and neuroticism in explaining the stress-distress relationship.
1079 Psychotherapy and Psychosomatics. DOI: 10.1159/000012346.
1080 Kaufman L. 2009.Mr. Whipple Left It Out: Soft Is Rough on Forests. Available at
1081 https://www.nytimes.com/2009/02/26/science/earth/26charmin.html
1082 Keane MP, Neal T. 2020. Consumer Panic in the COVID-19 Pandemic. SSRN Electronic
1083 Journal. DOI: 10.2139/ssrn.3600018.
1084 Kendell R, Jablensky A. 2003. Distinguishing between the validity and utility of psychiatric
1085 diagnoses. American Journal of Psychiatry. DOI: 10.1176/appi.ajp.160.1.4.
1086 Kendler KS, Kuhn J, Prescott CA. 2004. The Interrelationship of Neuroticism, Sex, and Stressful
1087 Life Events in the Prediction of Episodes of Major Depression. American Journal of Psychiatry.
1088 DOI: 10.1176/appi.ajp.161.4.631.
1089 Kim ES, Chin BS, Kang CK, Kim NJ, Kang YM, Choi JP, Oh DH, Kim JH, Koh B, Kim SE,
1090 Yun NR, Lee JH, Kim JY, Kim Y, Bang JH, Song KH, Kim H Bin, Chung K hyun, Oh M don.
1091 2020. Clinical course and outcomes of patients with severe acute respiratory syndrome
1092 coronavirus 2 infection: A preliminary report of the first 28 patients from the korean cohort study
1093 on COVID-19. Journal of Korean Medical Science. DOI: 10.3346/JKMS.2020.35.E142.
1094 Kim SE, Kim HN, Cho J, Kwon MJ, Chang Y, Ryu S, Shin H, Kim HL. 2016. Direct and
1095 indirect effects of five factor personality and gender on depressive symptoms mediated by
1096 perceived stress. PLoS ONE. DOI: 10.1371/journal.pone.0154140.

1097   Kirk CP, Rifkin LS. 2020. I'll trade you diamonds for toilet paper: Consumer reacting, coping
1098   and adapting behaviors in the COVID-19 pandemic. Journal of Business Research. DOI:
1099   10.1016/j.jbusres.2020.05.028.
1100   Klimke A, Nitsche MA, Maurer K, Voss U. 2016. Case Report: Successful Treatment of
1101   Therapy-Resistant OCD with Application of Transcranial Alternating Current Stimulation
1102   (tACS). Brain Stimulation 9:463–465. DOI: 10.1016/j.brs.2016.03.005.
1103   Klopfenstein T, Kadiane-Oussou NJ, Royer PY, Toko L, Gendrin V, Zayet S. 2020. Diarrhea:
1104   An underestimated symptom in Coronavirus disease 2019. Clinics and Research in Hepatology
1105   and Gastroenterology. DOI: 10.1016/j.clinre.2020.04.002.
1106   Knoll C. 2020.Panicked Shoppers Empty Shelves as Coronavirus Anxiety Rises. Available at
1107   https://www.nytimes.com/2020/03/13/nyregion/coronavirus-panic-buying.html
1108   Koffman J, Gross J, Etkind SN, Selman L. 2020. Uncertainty and COVID-19: how are we to
1109   respond? Journal of the Royal Society of Medicine. DOI: 10.1177/0141076820930665.
1110   Landau D, Iervolino AC, Pertusa A, Santo S, Singh S, Mataix-Cols D. 2011. Stressful life events
1111   and material deprivation in hoarding disorder. Journal of Anxiety Disorders. DOI:
1112   10.1016/j.janxdis.2010.09.002.
1113   LaSalle-Ricci VH, Arnkoff DB, Glass CR, Crawley SA, Ronquillo JG, Murphy DL. 2006. The
1114   hoarding dimension of OCD: Psychological comorbidity and the five-factor personality model.
1115   Behaviour Research and Therapy. DOI: 10.1016/j.brat.2005.11.009.
1116   Lawrence LM, Ciorciari J, Kyrios M. 2014. Relationships that compulsive buying has with
1117   addiction, obsessive-compulsiveness, hoarding, and depression. Comprehensive Psychiatry.
1118   DOI: 10.1016/j.comppsych.2014.03.005.
1119   Lechien JR, Chiesa-Estomba CM, De Siati DR, Horoi M, Le Bon SD, Rodriguez A, Dequanter
1120   D, Blecic S, El Afia F, Distinguin L, Chekkoury-Idrissi Y, Hans S, Delgado IL, Calvo-Henriquez
1121   C, Lavigne P, Falanga C, Barillari MR, Cammaroto G, Khalife M, Leich P, Souchay C, Rossi C,
1122   Journe F, Hsieh J, Edjlali M, Carlier R, Ris L, Lovato A, De Filippis C, Coppee F, Fakhry N,
1123   Ayad T, Saussez S. 2020. Olfactory and gustatory dysfunctions as a clinical presentation of mild-
1124   to-moderate forms of the coronavirus disease (COVID-19): a multicenter European study.
1125   European Archives of Oto-Rhino-Laryngology. DOI: 10.1007/s00405-020-05965-1.
1126   Lei Z, Cao H, Jie Y, Huang Z, Guo X, Chen J, Peng L, Cao H, Dai X, Liu J, Li X, Zhu J, Xu W,
1127   Chen D, Gao Z, He JR, Lin BL. 2020. A cross-sectional comparison of epidemiological and
1128   clinical features of patients with coronavirus disease (COVID-19) in Wuhan and outside Wuhan,
1129   China. Travel Medicine and Infectious Disease. DOI: 10.1016/j.tmaid.2020.101664.
1130   Li XY, Dai WJ, Wu SN, Yang XZ, Wang HG. 2020a. The occurrence of diarrhea in COVID-19
1131   patients. Clinics and Research in Hepatology and Gastroenterology. DOI:
1132   10.1016/j.clinre.2020.03.017.
1133   Li L quan, Huang T, Wang Y qing, Wang Z ping, Liang Y, Huang T bi, Zhang H yun, Sun W,
1134   Wang Y. 2020b. COVID-19 patients' clinical characteristics, discharge rate, and fatality rate of
1135   meta-analysis. Journal of Medical Virology. DOI: 10.1002/jmv.25757.

1136 Li Y, Marques L, Hinton DE, Wang Y, Xiao ZP. 2009. Symptom dimensions in Chinese patients
1137 with obsessive-compulsive disorder. CNS Neuroscience and Therapeutics. DOI: 10.1111/j.1755-
1138 5949.2009.00099.x.
1139 Li J, Wang X, Chen J, Zuo X, Zhang H, Deng A. 2020c. COVID-19 infection may cause ketosis
1140 and ketoacidosis. Diabetes, Obesity and Metabolism. DOI: 10.1111/dom.14057.
1141 Liu K, Fang YY, Deng Y, Liu W, Wang MF, Ma JP, Xiao W, Wang YN, Zhong MH, Li CH, Li
1142 GC, Liu HG. 2020. Clinical characteristics of novel coronavirus cases in tertiary hospitals in
1143 Hubei Province. Chinese medical journal. DOI: 10.1097/CM9.0000000000000744.
1144 Malcom AH. 1974. The "shortage" of bathroom tissue: a classic study in rumor. New York
1145 Times.
1146 Marian J.Study Reveals Hand-Washing Habits of Europeans. Available at
1147 https://jakubmarian.com/a-study-reveals-how-many-europeans-wash-their-hands-with-soap/
1148 Mataix-Cols D, Frost RO, Pertusa A, Clark LA, Saxena S, Leckman JF, Stein DJ, Matsunaga H,
1149 Wilhelm S. 2010. Hoarding disorder: A new diagnosis for DSM-V? Depression and Anxiety.
1150 DOI: 10.1002/da.20693.
1151 McEwen BS. 1998. Stress, adaptation, and disease. Allostasis and allostatic load. Annals of the
1152 New York Academy of Sciences 840:33–44. DOI: 10.1111/j.1749-6632.1998.tb09546.x.
1153 McEwen BS. 2001. From molecules to mind. Stress, individual differences, and the social
1154 environment. Annals of the New York Academy of Sciences. DOI: 10.1111/j.1749-
1155 6632.2001.tb03469.x.
1156 McEwen BS. 2003. Mood disorders and allostatic load. Biological Psychiatry 54:200–207. DOI:
1157 10.1016/S0006-3223(03)00177-X.
1158 Miri SM, Roozbeh F, Omranirad A, Alavian SM. 2020. Panic of Buying Toilet Papers: A
1159 Historical Memory or a Horrible Truth? Systematic Review of Gastrointestinal Manifestations of
1160 COVID-19. Hepatitis Monthly 20. DOI: 10.5812/hepatmon.102729.
1161 Mitchell E, Tavares TP, Palaniyappan L, Finger EC. 2019. Hoarding and obsessive–compulsive
1162 behaviours in frontotemporal dementia: Clinical and neuroanatomic associations. Cortex. DOI:
1163 10.1016/j.cortex.2019.09.012.
1164 Moher D, Liberati A, Tetzlaff J, Altman DG. 2009. Preferred reporting items for systematic
1165 reviews and meta-analyses: the PRISMA statement. BMJ 339:b2535–b2535. DOI:
1166 10.1136/bmj.b2535.
1167 Moritz S, Köther U, Hartmann M, Lincoln TM. 2015. Stress is a bad advisor. Stress primes poor
1168 decision making in deluded psychotic patients. European Archives of Psychiatry and Clinical
1169 Neuroscience. DOI: 10.1007/s00406-015-0585-1.
1170 Murad MH, Sultan S, Haffar S, Bazerbachi F. 2018. Methodological quality and synthesis of
1171 case series and case reports. Evidence-Based Medicine. DOI: 10.1136/bmjebm-2017-110853.
1172 Nestadt G, Di CZ, Riddle MA, Grados MA, Greenberg BD, Fyer AJ, McCracken JT, Rauch SL,
1173 Murphy DL, Rasmussen SA, Cullen B, Pinto A, Knowles JA, Piacentini J, Pauls DL, Bienvenu
1174 OJ, Wang Y, Liang KY, Samuels JF, Roche KB. 2009. Obsessive-compulsive disorder:

1175   Subclassification based on co-morbidity. Psychological Medicine. DOI:
1176   10.1017/S0033291708004753.
1177   Nolte T, Guiney J, Fonagy P, Mayes LC, Luyten P. 2011. Interpersonal stress regulation and the
1178   development of anxiety disorders: An attachment-based developmental framework. Frontiers in
1179   Behavioral Neuroscience. DOI: 10.3389/fnbeh.2011.00055.
1180   Nordsletten AE, Fernández de la Cruz L, Aluco E, Alonso P, López-Solà C, Menchón JM,
1181   Nakao T, Kuwano M, Yamada S, Fontenelle LF, Campos-Lima AL, Mataix-Cols D. 2018. A
1182   transcultural study of hoarding disorder: Insights from the United Kingdom, Spain, Japan, and
1183   Brazil. Transcultural Psychiatry. DOI: 10.1177/1363461518759203.
1184   Nordsletten AE, Reichenberg A, Hatch SL, Fernández De La Cruz L, Pertusa A, Hotopf M,
1185   Mataix-Cols D. 2013. Epidemiology of hoarding disorder. British Journal of Psychiatry. DOI:
1186   10.1192/bjp.bp.113.130195.
1187   Notes, Short Comments, and Answers to Correspondents: Medicated paper. 1869. Lancet
1188   94:531.
1189   Nugent KL, Chiappelli J, Rowland LM, Hong LE. 2015. Cumulative stress pathophysiology in
1190   schizophrenia as indexed by allostatic load. Psychoneuroendocrinology 60:120–129. DOI:
1191   10.1016/j.psyneuen.2015.06.009.
1192   O'Connor N, Clark S. 2019. Beware bandwagons! The bandwagon phenomenon in medicine,
1193   psychiatry and management. Australasian Psychiatry. DOI: 10.1177/1039856219848829.
1194   Ong J, Young BE, Ong S. 2020. COVID-19 in gastroenterology: A clinical perspective. Gut.
1195   DOI: 10.1136/gutjnl-2020-321051.
1196   Oosterhoff B, Palmer CA. 2020. Attitudes and Psychological Factors Associated With News
1197   Monitoring, Social Distancing, Disinfecting, and Hoarding Behaviors Among US Adolescents
1198   During the Coronavirus Disease 2019 Pandemic. JAMA pediatrics. DOI:
1199   10.1001/jamapediatrics.2020.1876.
1200   Pan L, Mu M, Yang P, Sun Y, Wang R, Yan J, Li P, Hu B, Wang J, Hu C, Jin Y, Niu X, Ping R,
1201   Du Y, Li T, Xu G, Hu Q, Tu L. 2020. Clinical characteristics of COVID-19 patients with
1202   digestive symptoms in Hubei, China: A descriptive, cross-sectional, multicenter study. American
1203   Journal of Gastroenterology. DOI: 10.14309/ajg.0000000000000620.
1204   People practicing open defecation, rural (% of rural population). Available at
1205   https://data.worldbank.org/indicator/SH.STA.ODFC.RU.ZS
1206   People practicing open defecation, urban (% of urban population). Available at
1207   https://data.worldbank.org/indicator/SH.STA.ODFC.UR.ZS
1208   Pertusa A, Frost RO, Fullana MA, Samuels J, Steketee G, Tolin D, Saxena S, Leckman JF,
1209   Mataix-Cols D. 2010. Refining the diagnostic boundaries of compulsive hoarding: A critical
1210   review. Clinical Psychology Review. DOI: 10.1016/j.cpr.2010.01.007.
1211   Pertusa A, Fullana MA, Singh S, Alonso P, Menchón JM, Mataix-Cols D. 2008. Compulsive
1212   hoarding: OCD symptom, distinct clinical syndrome, or both? American Journal of Psychiatry.
1213   DOI: 10.1176/appi.ajp.2008.07111730.

1214 Postlethwaite A, Kellett S, Mataix-Cols D. 2019. Prevalence of Hoarding Disorder: A systematic
1215 review and meta-analysis. Journal of Affective Disorders. DOI: 10.1016/j.jad.2019.06.004.
1216 Pot-Kolder R, Veling W, Counotte J, Van Der Gaag M. 2018. Self-reported Cognitive Biases
1217 Moderate the Associations between Social Stress and Paranoid Ideation in a Virtual Reality
1218 Experimental Study. Schizophrenia Bulletin. DOI: 10.1093/schbul/sbx119.
1219 Rector NA, Hood K, Richter MA, Michael Bagby R. 2002. Obsessive-compulsive disorder and
1220 the five-factor model of personality: Distinction and overlap with major depressive disorder.
1221 Behaviour Research and Therapy. DOI: 10.1016/S0005-7967(02)00024-4.
1222 Riley DS, Barber MS, Kienle GS, Aronson JK, von Schoen-Angerer T, Tugwell P, Kiene H,
1223 Helfand M, Altman DG, Sox H, Werthmann PG, Moher D, Rison RA, Shamseer L, Koch CA,
1224 Sun GH, Hanaway P, Sudak NL, Kaszkin-Bettag M, Carpenter JE, Gagnier JJ. 2017. CARE
1225 guidelines for case reports: explanation and elaboration document. Journal of Clinical
1226 Epidemiology. DOI: 10.1016/j.jclinepi.2017.04.026.
1227 Rothschild AJ. 2013. Challenges in the treatment of major depressive disorder with psychotic
1228 features. Schizophrenia Bulletin. DOI: 10.1093/schbul/sbt046.
1229 Russell G, Lightman S. 2019. The human stress response. Nature Reviews Endocrinology. DOI:
1230 10.1038/s41574-019-0228-0.
1231 Saint-Martin P, Bouyssy M, O'Byrne P. 2007. An unusual case of suicidal asphyxia by
1232 smothering. Journal of forensic and legal medicine 14:39–41. DOI: 10.1016/j.jcfm.2005.11.015.
1233 Saint-Martin P, Lefrancq T, Sauvageau A. 2012. Homicidal smothering on toilet paper: A case
1234 report. Journal of forensic and legal medicine 19:234–235. DOI: 10.1016/j.jflm.2011.12.032.
1235 Samuels JF, Bienvenu OJ, Pinto A, Murphy DL, Piacentini J, Rauch SL, Fyer AJ, Grados MA,
1236 Greenberg BD, Knowles JA, McCracken JT, Cullen B, Riddle MA, Rasmussen SA, Pauls DL,
1237 Liang KY, Hoehn-Saric R, Pulver AE, Nestadt G. 2008. Sex-specific clinical correlates of
1238 hoarding in obsessive-compulsive disorder. Behaviour Research and Therapy. DOI:
1239 10.1016/j.brat.2008.06.005.
1240 Satici B, Saricali M, Satici SA, Griffiths MD. 2020. Intolerance of Uncertainty and Mental
1241 Wellbeing: Serial Mediation by Rumination and Fear of COVID-19. International Journal of
1242 Mental Health and Addiction. DOI: 10.1007/s11469-020-00305-0.
1243 Sauvageau A, Yesovitch R. 2006. Choking on toilet paper: an unusual case of suicide and a
1244 review of the literature on suicide by smothering, strangulation, and choking. The American
1245 journal of forensic medicine and pathology 27:173–174. DOI:
1246 10.1097/01.paf.0000203269.97907.a7.
1247 Schrotenboer B. 2020.Coronavirus and shopping for supplies: Getting to the bottom of the toilet
1248 paper shortage. Available at https://eu.usatoday.com/story/money/2020/04/08/coronavirus-
1249 shortage-where-has-all-the-toilet-paper-gone/2964143001/
1250 Shaw AM, Timpano KR. 2016. An Experimental Investigation of the Effect of Stress on Saving
1251 and Acquiring Behavioral Tendencies: The Role of Distress Tolerance and Negative Urgency.
1252 Behavior Therapy. DOI: 10.1016/j.beth.2015.10.003.

1253   Sim K, Chua HC, Vieta E, Fernandez G. 2020. The anatomy of panic buying related to the
1254   current COVID-19 pandemic. Psychiatry Research. DOI: 10.1016/j.psychres.2020.113015.
1255   Skene J. 2019. The issue with tissue: how americans are flushing forests down the toilet.
1256   Smith K, Bryant RA. 2000. The generality of cognitive bias in acute stress disorder. Behaviour
1257   Research and Therapy. DOI: 10.1016/S0005-7967(99)00096-0.
1258   Smyth R. 2012. Bum Fodder: An Absorbing History of Toilet Paper. London: Souvenir Press
1259   Limited.
1260   Soria V, Uribe J, Salvat-Pujol N, Palao D, Menchón JM, Labad J. 2018.
1261   Psychoneuroimmunology of mental disorders. Revista de Psiquiatria y Salud Mental. DOI:
1262   10.1016/j.rpsm.2017.07.006.
1263   Steketee G, Frost R. 2003. Compulsive hoarding: Current status of the research. Clinical
1264   Psychology Review. DOI: 10.1016/j.cpr.2003.08.002.
1265   Storch EA, Nadeau JM, Johnco C, Timpano K, McBride N, Jane Mutch P, Lewin AB, Murphy
1266   TK. 2016. Hoarding in Youth with Autism Spectrum Disorders and Anxiety: Incidence, Clinical
1267   Correlates, and Behavioral Treatment Response. Journal of Autism and Developmental
1268   Disorders. DOI: 10.1007/s10803-015-2687-z.
1269   Supermarket boss's blunt reply to toilet paper hoarder wanting refund. 2020. Available at
1270   https://www.news.com.au/finance/business/retail/supermarket-bosss-blunt-reply-to-toilet-paper-
1271   hoarder-wanting-refund/news-story/985cc7022ce371a71b7d86c3031e2ce5
1272   Tissue and Hygiene Paper Report 2019 - Toilet Paper. 2019. Available at
1273   https://www.statista.com/study/48850/tissue-and-hygiene-paper-report-toilet-paper/
1274   Toilet Paper and Climate Change: NRDC's Updated "Issue With Tissue" Ranks Brands on
1275   Sustainability. 2020. Available at https://www.nrdc.org/media/2020/200618-20
1276   Toilet paper is getting less sustainable, researchers warn. 2019. Available at
1277   http://www.europeancleaningjournal.com/magazine/web-articles/latest-news/toilet-paper-is-
1278   getting-less-sustainable-researchers-warn
1279   Tolin DF, Meunier SA, Frost RO, Steketee G. 2010. Course of compulsive hoarding and its
1280   relationship to life events. Depression and Anxiety. DOI: 10.1002/da.20684.
1281   Tolin DF, Meunier SA, Frost RO, Steketee G. 2011. Hoarding among patients seeking treatment
1282   for anxiety disorders. Journal of Anxiety Disorders. DOI: 10.1016/j.janxdis.2010.08.001.
1283   Törnberg P. 2018. Echo chambers and viral misinformation: Modeling fake news as complex
1284   contagion. PLoS ONE. DOI: 10.1371/journal.pone.0203958.
1285   UK supermarkets ration toilet paper to prevent stockpiling. 2020. Available at
1286   https://www.theguardian.com/world/2020/mar/08/coronavirus-stockpiling-supermarkets-toilet-
1287   paper-hand-gel
1288   Vogel B, Trotzke P, Steins-Loeber S, Schäfer G, Stenger J, De Zwaan M, Brand M, Müller A.
1289   2019. An experimental examination of cognitive processes and response inhibition in patients
1290   seeking treatment for buying-shopping disorder. PLoS ONE. DOI:
1291   10.1371/journal.pone.0212415.

1292 Vosoughi S, Roy D, Aral S. 2018. The spread of true and false news online. Science. DOI:
1293 10.1126/science.aap9559.
1294 Wang X, Fang J, Zhu Y, Chen L, Ding F, Zhou R, Ge L, Wang F, Chen Q, Zhang Y, Zhao Q.
1295 2020a. Clinical characteristics of non-critically ill patients with novel coronavirus infection
1296 (COVID-19) in a Fangcang Hospital. Clinical Microbiology and Infection. DOI:
1297 10.1016/j.cmi.2020.03.032.
1298 Wang X, Liu W, Zhao J, Lu Y, Wang X, Yu C, Hu S, Shen N, Liu W, Sun Z, Li W. 2020b.
1299 Clinical characteristics of 80 hospitalized frontline medical workers infected with COVID-19 in
1300 Wuhan, China. Journal of Hospital Infection. DOI: 10.1016/j.jhin.2020.04.019.
1301 Wang Z, Wang Y, Zhao Q, Jiang K. 2016. Is the DSM-5 hoarding disorder diagnosis valid in
1302 China? Shanghai Archives of Psychiatry. DOI: 10.11919/j.issn.1002-0829.215054.
1303 Wang W, Xu Y, Gao R, Lu R, Han K, Wu G, Tan W. 2020c. Detection of SARS-CoV-2 in
1304 Different Types of Clinical Specimens. JAMA - Journal of the American Medical Association.
1305 DOI: 10.1001/jama.2020.3786.
1306 Wei XS, Wang X, Niu YR, Ye LL, Peng WB, Wang ZH, Yang WB, Yang BH, Zhang JC, Ma
1307 WL, Wang XR, Zhou Q. 2020. Diarrhea is associated with prolonged symptoms and viral
1308 carriage in COVID-19. Clinical gastroenterology and hepatology : the official clinical practice
1309 journal of the American Gastroenterological Association. DOI: 10.1016/j.cgh.2020.04.030.
1310 Wells G, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. 2012. The Newcastle-
1311 Ottawa Scale (NOS) for assessing the quality if nonrandomized studies in meta-analyses.
1312 (Available from: URL: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp). DOI:
1313 10.2307/632432.
1314 Wheaton MG, Abramowitz JS, Jacoby RJ, Zwerling J, Rodriguez CI. 2016. An investigation of
1315 the role of intolerance of uncertainty in hoarding symptoms. Journal of Affective Disorders.
1316 DOI: 10.1016/j.jad.2015.12.047.
1317 White J. 2020.Lionel Messi takes on '10-touch toilet paper challenge' during coronavirus
1318 lockdown. Available at https://www.scmp.com/sport/football/article/3076057/lionel-messi-takes-
1319 10-touch-toilet-paper-challenge-during
1320 Wong G, Greenhalgh T, Westhorp G, Buckingham J, Pawson R. 2013. RAMESES publication
1321 standards: Realist syntheses. BMC Medicine. DOI: 10.1186/1741-7015-11-21.
1322 Wong SH, Lui RNS, Sung JJY. 2020. Covid-19 and the digestive system. Journal of
1323 Gastroenterology and Hepatology (Australia). DOI: 10.1111/jgh.15047.
1324 Wood KA. 2020.A Psychoanalysis of Toilet Paper and Freudian Wisdom in the Corona-
1325 pocalypse. Available at https://medium.com/@kristiewood/a-psychoanalysis-of-toilet-paper-
1326 freudian-wisdom-in-the-corona-pocalypse-e664f2c2e3c6
1327 Worobey M, Cox J, Gill D. 2019. The origins of the great pandemic. Evolution, Medicine and
1328 Public Health. DOI: 10.1093/emph/eoz001.
1329 Xiao F, Tang M, Zheng X, Liu Y, Li X, Shan H. 2020. Evidence for Gastrointestinal Infection of
1330 SARS-CoV-2. Gastroenterology. DOI: 10.1053/j.gastro.2020.02.055.

1331   Xu Y, Li X, Zhu B, Liang H, Fang C, Gong Y, Guo Q, Sun X, Zhao D, Shen J, Zhang H, Liu H,
1332   Xia H, Tang J, Zhang K, Gong S. 2020a. Characteristics of pediatric SARS-CoV-2 infection and
1333   potential evidence for persistent fecal viral shedding. Nature Medicine. DOI: 10.1038/s41591-
1334   020-0817-4.
1335   Xu XW, Wu XX, Jiang XG, Xu KJ, Ying LJ, Ma CL, Li SB, Wang HY, Zhang S, Gao HN,
1336   Sheng JF, Cai HL, Qiu YQ, Li LJ. 2020b. Clinical findings in a group of patients infected with
1337   the 2019 novel coronavirus (SARS-Cov-2) outside of Wuhan, China: Retrospective case series.
1338   The BMJ. DOI: 10.1136/bmj.m606.
1339   Yeo C, Kaushal S, Yeo D. 2020. Enteric involvement of coronaviruses: is faecal–oral
1340   transmission of SARS-CoV-2 possible? The Lancet Gastroenterology and Hepatology. DOI:
1341   10.1016/S2468-1253(20)30048-0.
1342   Yu R. 2016. Stress potentiates decision biases: A stress induced deliberation-to-intuition (SIDI)
1343   model. Neurobiology of Stress. DOI: 10.1016/j.ynstr.2015.12.006.
1344   Yu M, Westenberg PM, Li W, Wang J, Miers AC. 2019. Cultural evidence for interpretation bias
1345   as a feature of social anxiety in Chinese adolescents. Anxiety, Stress and Coping. DOI:
1346   10.1080/10615806.2019.1598556.
1347   Zhang H, Li HB, Lyu JR, Lei XM, Li W, Wu G, Lyu J, Dai ZM. 2020a. Specific ACE2
1348   expression in small intestinal enterocytes may cause gastrointestinal symptoms and injury after
1349   2019-nCoV infection. International Journal of Infectious Diseases. DOI:
1350   10.1016/j.ijid.2020.04.027.
1351   Zhang J, Liu P, Wang M, Wang J, Chen J, Yuan W, Li M, Xie Z, Dong W, Li H, Zhao Y, Wan
1352   L, Chu T, Wang L, Zhang H, Tao T, Ma J. 2020b. The clinical data from 19 critically ill patients
1353   with coronavirus disease 2019: a single-centered, retrospective, observational study. Journal of
1354   Public Health (Germany). DOI: 10.1007/s10389-020-01291-2.
1355   Zhao XY, Xu XX, Yin H Sen, Hu QM, Xiong T, Tang YY, Yang AY, Yu BP, Huang ZP. 2020.
1356   Clinical characteristics of patients with 2019 coronavirus disease in a non-Wuhan area of Hubei
1357   Province, China: A retrospective study. BMC Infectious Diseases. DOI: 10.1186/s12879-020-
1358   05010-w.
1359   Zhou N. 2020. Off the chart: Australians were world leaders in panic buying, beating UK and
1360   Italy. The Guardian.
1361   Zhu J, Ji P, Pang J, Zhong Z, Li H, He C, Zhang J, Zhao C. 2020. Clinical characteristics of
1362   3,062 COVID-19 patients: a meta-analysis. Journal of Medical Virology. DOI:
1363   10.1002/jmv.25884.
1364

CMO scheme of the realist review

1   Table 1. CMO scheme of the realist review

Context	Mechanisms	Outcome
COVID-19 pandemic	M1. COVID-19 disease is associated with diarrhoea (or polyuria), which contributes to the panic buying and toilet paper hoarding	Toilet paper hoarding
	M2. Social cognitive biases and social media are facilitators of toilet paper hoarding in the general population	
	M3. The COVID-19 pandemic is a stressful event that causes the exacerbation of mental illnesses and hoarding behaviours leading to toilet paper hoarding	
	M4. Cultural aspects moderate the relationship between the COVID-19 pandemic and toilet paper hoarding, with differences between countries	

Main characteristics of studies included in the Systematic Review (n=6).

1 **Table 2. Main characteristics of studies included in the Systematic Review (n=6)**

Case	Author, year of publication	Age (y.o)	Gender	Substance use	Comorbid psychiatric diagnosis	Treatment	Primary outcome (toilet paper)	Secondary outcomes	Checklist CARE guidelines	
									Completed items	Missing sub-items*,#
1	Klimke et al., 2016 [20]	17	Man	NR	OCD	tACS, lorazepam 0.5 mg day,	Before treatment: use of 10 rolls of toilet paper After treatment (2 stimulations): 1 roll of toilet paper	None	8/13	5c, 5d, 6, 7, 8a, 8b, 10c
2	Sauvageau and Yesovitch 2006 [21]	58	Man	NR	Schizophrenia	NR	No hoarding behaviour	Suicidal asphyxia by toilet paper	12/13	5c, 5d
3	Saint-Martin et al., 2007 [22]	30	Man	NR	BPD	Psychotropic drugs: antidepressant, tranquilizers and conventional antipsychotics	No hoarding behaviour	Suicidal asphyxia by toilet paper ingurgitation	12/13	5c, 5d
4	Saint-Martin et al., 2012 [23]	91	Woman	NR	Alzheimer's disease	NA	No hoarding behaviour	Homicidal asphyxia by toilet paper	12/13	5c, 5d
5	Fisher et al., 2014 [24]	30	Man	NR	Pica	NR	No hoarding behaviour	Gastritis by toilet paper ingestion (Pica)	10/13	5d, 7, 10c
6	Chisholm and Martin, 1981 [25]	37	Woman	NR	Pica	Zinc and ferrous sulfate	No hoarding behaviour	Pica by toilet paper ingestion	12/13	5c

3 *Checklist items from CARE guidelines include: 1, 2, 3a, 3b, 3c, 3d, 4, 5a, 5b, 5c, 5d, 6, 7, 8a, 8b, 8c, 8d, 9a, 9b, 9c, 10a, 10b, 10c, 10d, 11a, 11b, 11c, 11d, 12,
4 13.

5   # Items that are not applicable for the case report are not included in this section.

6   **Abbreviations: BDP, Borderline Personality Disorder; OCD, Obsessive Compulsive Disorder; NA, Not applicable; NR, not reported; tACS,**
7   **transcranial alternating current stimulation; y.o., years old;**

Figure 1

PRISMA flow diagram of the studies included in the systematic review.
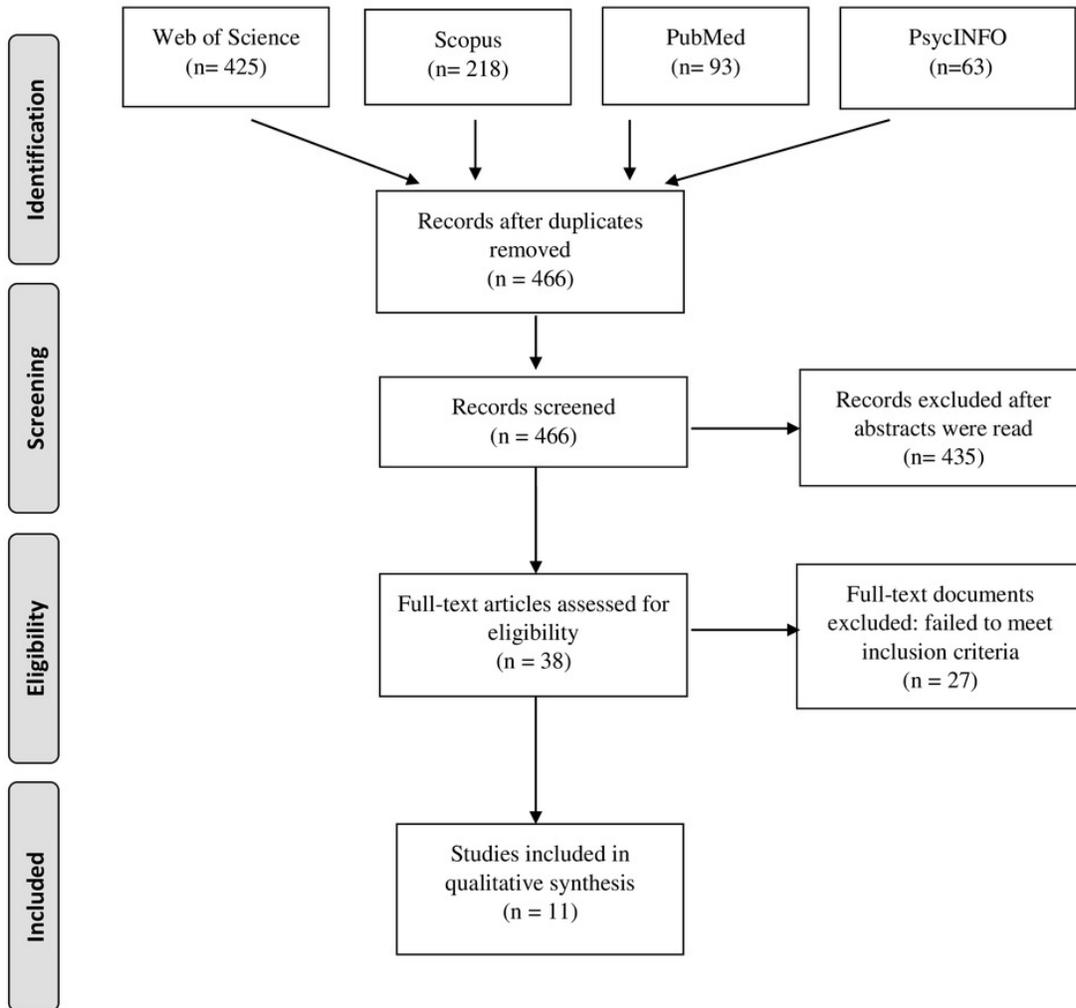
Figure 2

Google search trends for the term 'toilet paper' by different English-speaking countries.

(A) Australia. (B) USA. (C) Canada. (D) United Kingdom. (E) India.

A.

Australia

Peak: 1st-7th March 2020

B.

USA

Peak: 15th-21st March 2020

C.

Canada

Peak: 8th-14th March 2020

D.

United Kingdom

Peak: 15th-21st March 2020

E.

India

Peak: 18th-24th August 2019
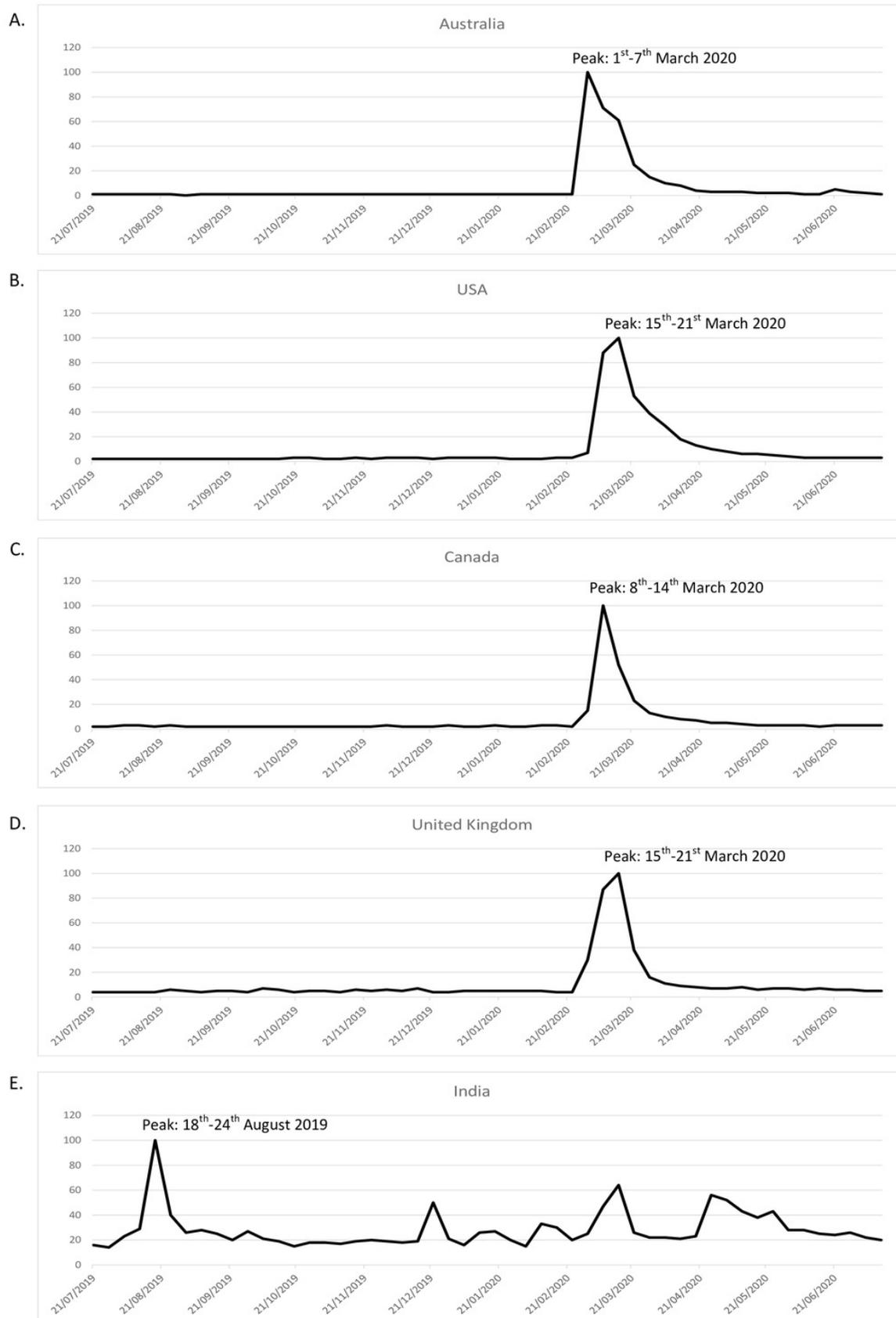
Figure 3

Figure 3. CATOTIM algorithm for managing paper toilet hoarding.

Abbreviations: CATOTIM= Catalan Toilet Tissue Research Group in Mental Health; PTSD= Post-traumatic stress disorder; CT= Computed tomography; MRI= Magnetic resonance imaging; CSF= Cerebrospinal fluid; Shizoaffective D.= Schizoaffective disorder; OCD= Obsessive-compulsive disorder; DSM-5= Diagnostic and Statistical Manual of Mental Disorders – 5th edition; GAD= Generalised anxiety disorder; OCPD= Obsessive-compulsive personality disorder.