

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

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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 (systematic review). PubMed, pre-prints and grey literature were also searched (realist review). The databases were searched from inception until June 2020.

Study selection: There were no restrictions on the study design.

Outcomes and measures: For the systematic review, toilet paper hoarding was the main outcome, and pathological use of toilet paper was the secondary outcome. For the realist review, the context-mechanisms-outcome (CMO) scheme included the COVID-19 pandemic (context), four proposed mechanisms, and one outcome (toilet paper hoarding). The four potential mechanisms were 1) gastrointestinal mechanisms 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 studies of human populations were considered (including general population studies and clinical studies of patients suffering from mental health problems).

Results: The systematic review identified 14 studies (8 studies for the main outcome, 6 studies for the secondary outcome). Three surveys identified the role of the COVID-19 threat in toilet paper hoarding in the general population. 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 the perceived threat of COVID-19 on toilet paper buying and stockpiling. Six case reports of pathological 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 the mechanisms, social cognitive biases and a bandwagon effect were potential contributors to 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 hoarding 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, fear of contagion, or particular personality traits (conscientiousness), are likely to be involved.

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23

24 **Abstract**

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51 and Singapore).

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59 Introduction

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 paper has been used for faecal-related cleaning purposes since the end
63 of the 6th century in China, although the toilet paper industry blossomed in the early 14th century in
64 China during the reign of the Yang dynasty (Smyth, 2012). The commercial use of toilet paper started in
65 1857 thanks to Joseph Gayetty, a New York-based entrepreneur who sold medicated paper infused with
66 aloe that aimed to cure haemorrhoids (Smyth, 2012). The reception of toilet paper from the medical
67 community was not positive, and in an ironic note published in the *Lancet* in 1869, the idea of toilet paper
68 was defined as “the last absurdity” (*The Lancet*, 1869). The note was sarcastic when referring to the
69 opinion of Gayetty, who anticipated that “this article will be found in the household of every refined man
70 in the kingdom”. Many years later, toilet paper has become an essential product for a great proportion of
71 the population worldwide.

72 Since early December 2019, the coronavirus SARS-CoV-2 has spread from Wuhan (China) to many
73 countries worldwide, causing the coronavirus disease 2019 (COVID-19). In terms of deaths, COVID-19
74 has been the worst pandemic since the 1918 flu pandemic, also known as the Spanish flu (although its
75 origin was in Kansas, USA (Worobey, Cox & Gill, 2019)). By November 11th, 2020, the COVID-19
76 pandemic had caused at least 51,251,715 infections and 1,270,930 deaths (WHO Coronavirus Disease
77 (COVID-19) Dashboard). During the first months of the pandemic, medical masks were in short supply in
78 most countries. This issue was expected because SARS-CoV-2 is viable and infectious in aerosols for
79 hours (van Doremalen et al., 2020), and using face masks is advised in situations where meeting others is
80 likely, as masks can reduce the risk of transmitting the infection (Greenhalgh et al., 2020). The global
81 toilet paper shortage amid the coronavirus was much less expected, but in the weeks that followed the
82 pandemic spread, compulsive panic buying of toilet paper was observed in many countries on different
83 continents (Buchholz, 2020). Toilet paper became a co-star with coronavirus in the news in many
84 countries, with surprising information every week: rationing of toilet paper by supermarkets (Pidd, 2020),
85 toilet rolls being chained to their dispensers in public toilets (Lewis, 2020), armed robbers stealing
86 hundreds of paper rolls (Leung, 2020), and deserted supermarket and grocery shelves (Knoll, 2020).
87 People were buying and hoarding toilet paper even before it was known that the virus could be detected in
88 the faeces of infected patients (Chen et al., 2020a) or that approximately 10% of COVID-19 patients may
89 suffer from diarrhoea (Miri et al., 2020). Therefore, a scientific question demands an urgent response:
90 why do people hoard toilet paper?

91 We aimed to shed light on potential risk factors associated with toilet paper hoarding, with a particular
92 interest in stress-related situations such as the COVID-19 pandemic. As hoarding is often seen in patients
93 with obsessive-compulsive disorder (OCD) and other psychiatric disorders as well as in people with
94 obsessive-compulsive traits (Mataix-Cols et al., 2010), it is important to make the differential diagnosis
95 with mental health problems. In most individuals, compulsive hoarding appears to be a syndrome distinct
96 from OCD, which is associated with substantial levels of disability and social isolation (Pertusa et al.,
97 2008). This has led to the inclusion of hoarding as a separate diagnosis in the 5th edition of the Diagnostic
98 and Statistical Manual of Mental Disorders (DSM-5). One hoarding criterion is the acquisition of and
99 failure to discard a large number of possessions that seem to be useless or of limited value (Mataix-Cols
100 et al., 2010). We are not currently interested in addressing the debate about the utility of toilet paper, but
101 it is important to mention that to date, toilet paper is not a specifier of the DSM-5 diagnostic criteria for
102 hoarding. Moreover, there is no previous evidence suggesting that toilet paper hoarding is a behaviour

103 distinct from other hoarding behaviour. Epidemiological studies suggest that hoarders are older, often
104 unmarried, and more likely to be impaired by a current physical health condition or comorbid mental
105 disorder (Nordsletten et al., 2013). There is limited information regarding the prevalence of toilet paper
106 hoarding in the general population.

107 It is also important to underscore that compulsive buying and hoarding are two related phenomena, as
108 hoarding is a predictor of compulsive buying (Lawrence, Ciorciari & Kyrios, 2014). Moreover, people
109 with buying-shopping disorder report more hoarding symptoms than healthy control individuals (Vogel et
110 al., 2019). Both buying and hoarding behaviour have been described as being preceded by stressful life
111 events and traumatic experiences (Tolin et al., 2010; Landau et al., 2011; Vogel et al., 2019). For this
112 reason, it is important to study how stress influences hoarding behaviour because this knowledge would
113 help to understand some of the recent panic-buying behaviour seen in the weeks following the COVID-19
114 pandemic.

115 As hoarding behaviours are observed in both non-clinical (Bulli et al., 2014) and clinical (Pertusa et al.,
116 2008) samples, studies considering non-clinical populations need to be considered. It is also important to
117 analyse whether the mechanisms linking stress with toilet paper hoarding are shared by people with
118 mental disorders (hoarding disorders and other psychiatric disorders) and the general population or
119 whether this relationship might change depending upon the social or cultural context.

120 Neuroimaging studies using functional magnetic resonance imaging (fMRI) and conducting experimental
121 approaches (provocation of hoarding-related anxiety) in healthy subjects and clinical populations (OCD
122 patients) have demonstrated that hoarding symptoms are associated with activation of the same brain
123 areas, involving the anterior ventromedial prefrontal cortex, in both non-clinical and clinical populations
124 (Mataix-Cols et al., 2003; An et al., 2009). These results support a common transdiagnostic
125 neurobiological pathway for hoarding symptoms. Interestingly, the anterior ventromedial prefrontal
126 cortex has also been implicated in buying behaviour in studies exploring value-based decisions with a
127 buying task during an fMRI session (Gluth et al., 2012).

128 The main objective of our study was to identify potential mechanisms linking the context of a stressful
129 situation (COVID-19 pandemic) with a specific outcome (toilet paper hoarding). We also aimed to study
130 potential mechanisms involved in hoarding behaviour that might be influenced by psychopathological,
131 psychological, social and cultural determinants that could act as moderators.

132

133 To achieve these objectives, we conducted one study that included two sequential steps:
134 First, we conducted a systematic review exploring potential risk factors associated with toilet paper
135 hoarding. Psychopathology, personality and stress-related factors (including pandemics, especially the
136 COVID-19 pandemic) were considered. The main hypothesis of our systematic review was that a
137 substantial proportion of the general population would hoard toilet paper amid the COVID-19 pandemic.
138 As a secondary aim of the systematic review, we also wanted to study whether toilet paper use
139 (pathological use and/or hoarding) is associated with negative mental health outcomes (e.g., greater risk
140 of depression, suicide). This secondary aim was exploratory in nature.

141 Second, we conducted a realist review exploring different theory-driven mechanisms on potential
142 moderators of the relationship between the COVID-19 pandemic and toilet paper hoarding (Table 1). A
143 realist review is based on a realist philosophy of science and considers the interaction among context,
144 mechanism and outcome, also known as the CMO configuration (Wong et al., 2013). As explained in the
145 RAMESES guidelines for realist syntheses (Wong et al., 2013), this type of review uses the concept of a
146 mechanism for understanding the relationship between context and outcome. Several mechanisms might

147 be studied and can be defined as “underlying entities, processes, or (social) structures which operate in
148 particular contexts to generate outcomes of interest”. A realist review is an interpretative type of literature
149 review, in contrast with a systematic review that attempts to collect all empirical evidence that fits pre-
150 specified eligibility criteria in order to answer a specific research question (Berg & Nanavati, 2016).
151 Regarding the realist review, four hypotheses were formulated in relation to different mechanisms that
152 might partially explain toilet paper hoarding during the COVID-19 pandemic: 1) diarrhoea or polyuria
153 contributes to panic buying and toilet paper hoarding; 2) social cognitive biases and social media facilitate
154 the hoarding of toilet paper; 3) stress contributes to the worsening of mental health outcomes that could
155 also increase the risk of toilet paper hoarding; and 4) cultural aspects moderate the relationship between
156 the COVID-19 pandemic and toilet paper hoarding.
157 Finally, several recommendations for future research will be included considering the gaps in the
158 scientific literature. Clinical and ecological implications of our research will also be summarised.

159 **Materials & Methods**

160 **Systematic review**

161 Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines
162 (Moher et al., 2009) were followed. The protocol was registered in PROSPERO
163 (CRD42020182308).

164 Search strategy

165 Four electronic bibliographic databases were searched: PubMed, Web of Science, Scopus and
166 PsycINFO. The following search strategy was used: (Toilet AND (paper OR tissue OR roll))
167 AND (psychiatry OR psychology OR mental OR anxiety OR depression OR schizophrenia OR
168 bipolar OR psychosis OR delusion OR personality OR neuroticism OR obsessive OR hoarding
169 OR suicide OR stress* OR pandemic OR epidemic OR COVID-19 OR coronavirus OR virus).
170 The search strategy was performed by J.L. and A.G.R. Studies published through 31st October
171 2020 were considered for inclusion.

172 Inclusion and exclusion criteria

173 In our systematic review, toilet paper hoarding was considered the main outcome. This outcome
174 was defined as a behavioural pattern characterised by excessive acquisition of and an inability or
175 unwillingness to discard large quantities of toilet paper that cause significant distress or
176 impairment. This definition is in agreement with the current DSM-5 diagnostic category for
177 hoarding disorder, but it has been adapted for specifying that the main item saved is toilet paper.
178 We also conducted a secondary analysis for the systematic review that considers toilet paper
179 (pathological use or hoarding) as a risk factor for mental health outcomes (depression, suicide,
180 etc.).

181 In those studies using toilet paper as an outcome (e.g., toilet paper hoarding), all potential
182 exposures (stress-related situations, personality factors, psychopathology, and mental illnesses)
183 were considered. In those studies with toilet paper use as an exposure, the considered outcomes
184 were mental health problems (e.g., depression, suicide).

185 All types of studies that relate to mental health or stress-related aspects of toilet paper use were
186 included. There were no restrictions on the types of study design. All studies conducted in
187 human populations (general population studies and clinical studies of patients suffering from

188 mental health problems) were considered for inclusion. Language was restricted to articles
189 written English, Spanish, Catalan, Portuguese, Dutch, French, or German. There was no
190 restriction on the type of document indexed in the electronic databases (these documents could
191 include original articles, reviews, letters to the editor, case reports, editorials, conference
192 proceedings). We included published documents in the systematic review, and therefore,
193 preprints were not included in the systematic review (they could be included in the realist
194 review).

195 Data collection and extraction

196 All retrieved records were checked for duplicates using Covidence (<https://www.covidence.org/>).
197 The titles and/or abstracts of studies retrieved using the search strategy and those from additional
198 sources were screened independently by two review authors (J.L. and A.G.R.) to identify studies
199 that met the inclusion criteria. Any disagreement between them over the eligibility of particular
200 studies was resolved through discussion with two additional reviewers (J.C. and J.P). The flow
201 chart of all selected studies is described in Figure 1.

202

203 Risk of bias (quality) assessment

204 Quality assessment was conducted with the Newcastle Ottawa Scale (cohort and case-control
205 studies) (Wells et al., 2012) or the CARE guidelines (case reports) (Riley et al., 2017). Case
206 reports and case series are also rated with the tool for evaluating the methodological quality of
207 case reports and case series (Murad et al., 2018).

208

209 **Realist review**

210 A realist synthesis was conducted following the RAMESES guidelines (Wong et al., 2013). An
211 additional reviewer (J.C.) participated in the search for potential citations along with the two
212 researchers participating in the systematic review (J.L. and A.G.R.). We started by considering
213 all reviewed items in the previous step with the theory-driven approach of the realist review.
214 Four mechanisms were tested (Table 1). Iterative screening was completed by these reviewers,
215 who also conducted additional searches to explore these hypotheses on PubMed as well as grey
216 literature available on the internet (e.g., Google searching). Search terms differed for each
217 mechanism: 1) Mechanism 1: covid AND (diarrhoea OR polyuria); 2) Mechanism 2: (stress OR
218 covid OR pandemic) AND cognitive bias AND social; 3) Mechanism 3: (covid OR stress OR
219 pandemic) AND hoarding; and 4) Mechanism 4: (toilet paper OR hoarding) AND (culture OR
220 cultural). All potential abstracts were included if they could contribute to explaining any of the
221 four studied mechanisms linking the COVID-19 pandemic with toilet paper hoarding. The
222 identification and selection of citations were guided by these research questions and were based
223 on the trustworthiness of sources. This last characteristic is not easy to verify, as fake news is
224 mixed with real news all over the internet. We tried to reduce the inclusion of fake news by
225 carefully observing the sources, particularly when they came from non-peer-reviewed sources.

226

227 To explore differences in cultural aspects of toilet paper hoarding, we also verified the Google
228 search trending topics during the year of 2020 in the world (<https://trends.google.com/>). Previous
229 research indicates that Google search data are useful in predicting near-future consumer
230 behaviour (Goel et al., 2010). The search frequency on Google has also been proposed as a direct
231 measure of investor attention (Da, Engelberg & Gao, 2011). Data regarding the use of toilet
232 paper were graphed with Excel (Microsoft Corporation, USA) after downloading the .csv file.
233 We also compared two search terms (toilet paper vs covid) to analyse the relative popularity of
234 the term “toilet paper” with respect to the “COVID” term.
235 Qualitative studies and material were managed with the software QDA miner Lite version 2.0.7
236 (Provalis Research, Canada). Data regarding the potential contribution of the studied
237 mechanisms were extracted. To identify key elements of importance to the success or failure of a
238 mechanism in a certain context using a realist perspective, information was gathered on the
239 mechanism, the context and the actual “working of the mechanism”. The strength of the evidence
240 and the usefulness of the application of realist principles to available data were discussed.

241

242

243 **Results**

244 **Systematic review**

245 A total of 1337 records were identified in initial searches (Web of Science: 489; Scopus: 245,
246 PubMed: 532; PsycINFO: 71). After duplications were removed, 576 records were screened after
247 reading the title and abstract. Further details of the screening and selection processes can be
248 found in Figure 1. Finally, 13 studies were included because they were focused on toilet paper
249 hoarding behaviour and met our selection criteria.

250 Primary outcome: toilet paper hoarding

251 We identified 8 published studies related to the COVID-19 pandemic with toilet paper hoarding
252 (Garbe, Rau & Toppe, 2020; Kirk & Rifkin, 2020; Oosterhoff & Palmer, 2020; Sim et al., 2020;
253 Miri et al., 2020; Micalizzi et al., 2020; Laato et al., 2020; Güzel, 2020). One study included a
254 survey of participants focused on toilet paper shopping and stockpiling behaviours (Garbe, Rau
255 & Toppe, 2020), one study conducted a survey of adolescents regarding several pandemic-
256 related behaviours (including hoarding) (Oosterhoff & Palmer, 2020), and another study
257 conducted a survey through Amazon’s Mechanical Turk on stockpiling behaviour (including
258 toilet paper) in response to COVID-19 (Micalizzi et al., 2020). One study analysed purchasing
259 behaviour during the COVID-19 pandemic (Laato et al., 2020). The other four published studies
260 included theoretical discussions on consumption behaviours, including panic buying during the
261 COVID-19 pandemic (Kirk & Rifkin, 2020; Sim et al., 2020; Miri et al., 2020; Güzel, 2020).
262 The first study (Garbe, Rau & Toppe, 2020) explored the relationship between personality traits
263 based on the HEXACO model (Honesty-Humility, Emotionality, eXtraversion, Agreeableness,
264 Conscientiousness, and Openness to experience). This study was a survey that included a final
265 sample of 996 adults from 22 countries. Participants were asked about their perception of the
266 level of threat posed by COVID-19 and their toilet paper consumption behaviour (shopping

267 frequency, shopping intensity, number of toilet paper rolls stocked in their household). Older
268 participants shopped more frequently, bought more packages of toilet paper and had more toilet
269 paper rolls in stock than younger participants. Participants residing in Europe shopped for toilet
270 paper significantly more frequently than North American residents but had less toilet paper in
271 stock. In this study, participants were asked about whether they stocked toilet paper more than
272 usual, which could be considered an indirect measure of toilet paper hoarding. Of all participants
273 in the survey, 17.2% of North Americans and 13.7% of Europeans reported stockpiling toilet
274 paper. The perceived threat of COVID-19 was positively related to all three toilet paper variables
275 (shopping frequency, shopping intensity and toilet paper stockpiling). The HEXACO model
276 suggested that participants scoring high in conscientiousness (organisation, diligence,
277 perfectionism, and prudence) shopped for toilet paper more and stocked more toilet paper. This
278 study also included an additional analysis exploring the indirect effect of emotionality
279 (fearfulness, anxiety, dependence, and sentimentality) on toilet paper consumption. They found a
280 significant indirect effect of emotionality through the perceived threat of COVID-19 on shopping
281 intensity and the amount of stocked toilet paper rolls. In the quality assessment with the
282 Newcastle Ottawa Scale for this study, we considered the perceived threat of COVID-19 as the
283 main exposure and toilet paper behaviour as the main outcome (definition of cases). The quality
284 assessment yielded two stars for selection (representativeness of cases, selection of controls), two
285 stars for comparability and one star for the definition of the exposure. Therefore, this study
286 obtained 5 of 9 possible stars on the Newcastle Ottawa Scale.

287 Another survey of 770 adolescents in the United States explored the role of psychological factors
288 in pandemic-related behaviours during the COVID-19 outbreak (social distancing, disinfecting,
289 monitoring the news, hoarding supplies) (Oosterhoff & Palmer, 2020). In this study, attitudes
290 about the greater severity of COVID-19 and greater self-interest values were associated with
291 more hoarding, whereas greater social responsibility and social trust were associated with less
292 hoarding. In the quality assessment with the Newcastle Ottawa Scale for this study, we
293 considered attitudes about the severity of COVID-19 as the main exposure and hoarding
294 behaviour as the main outcome (definition of cases). This study obtained 5 out of 9 stars on the
295 Newcastle Ottawa Scale (selection [two stars], comparability [two stars], definition of exposure
296 [one star]).

297 One survey of 363 workers in the United States who were recruited from Amazon's Mechanical
298 Turk inquired about the stockpiling of 13 items, as well as opinions on the COVID-19 pandemic
299 and political affiliation (Democrat vs Republican) (Micalizzi et al., 2020). Of all 13 items, toilet
300 paper was the item most commonly stockpiled (63.2%). However, more than half of the sample
301 reported stockpiling other supplies, such as canned goods (59.2%), rice (57.4%), bottled water
302 (57.0%), pasta (56.2%), bread (53%) and medicine (52.7%). When looking at predictors of
303 increased stockpiling with multivariate analyses that were adjusted for education status, income,
304 age and number of people living at home, higher stockpiling was observed among those who
305 were more conservative, worried more about the pandemic, had more people in the home, and

306 reported less social distancing. This study obtained 4 out of 9 stars on the Newcastle Ottawa
307 Scale (selection [one star], comparability [two stars], definition of exposure [one star]).

308

309 Five studies reflected on potential explanations for toilet paper hoarding amid the COVID-19
310 pandemic and justified this behaviour with different hypotheses, such as a reaction to a threat to
311 product availability that increases the perceived need for the threatened object and makes
312 consumers behave with an emotionally reactive response (Kirk & Rifkin, 2020). Other potential
313 moderators included the conflict between the desire to maintain regular routines versus the
314 uncertainty of limiting access to daily necessities by the pandemic, a coping response to stressful
315 unmet situations or even a reaction to the loss of control of the future and social pressures to
316 conform to similar behaviours (Sim et al., 2020). Another study testing potential contributors of
317 toilet paper hoarding during the COVID-19 pandemic in a Finnish sample (Laato et al., 2020)
318 proposed a structured model connecting exposure to online information sources to two
319 behavioural responses (unusual purchases and voluntary self-isolation). Exposure to online
320 information increased health anxiety as measured by cyberchondria and consequently the
321 intention to make unusual purchases and engage in voluntary isolation.

322 In another systematic review on gastrointestinal symptoms of COVID-19 that indicates the long
323 persistence of COVID-19 in the gastrointestinal tract after primary treatment (Miri et al., 2020),
324 the authors suggested that these findings could explain the coronavirus-related panic buying of
325 toilet rolls.

326 Finally, another study was a personal reflection about the panic buying and hoarding of toilet
327 paper during the COVID-19 pandemic from a psychodynamic perspective (Güzel, 2020).

328

329 Secondary outcome: toilet paper (pathological use or hoarding) and mental health outcomes

330 Six case reports of pathological use of toilet paper hoarding were identified. One study reported a
331 case of a patient with therapy-resistant OCD who spent hours on the toilet with excessive anus
332 wiping, using at least 10 rolls of toilet paper per day (Klimke et al., 2016). Interestingly, with
333 only two applications of transcranial alternating current stimulation (tACS), the patient showed
334 immediate improvement (using less than one toilet roll per day).

335 Two case reports indicated suicide by mechanical asphyxia using toilet paper: one patient
336 suffering from schizophrenia (Sauvageau & Yesovitch, 2006) and another patient with borderline
337 personality disorder (Saint-Martin, Bouyssy & O'Byrne, 2007). It is not always easy to
338 distinguish suicide from homicide, and another study reported the case of a homicide by toilet
339 paper smothering in a patient with Alzheimer's disease (Saint-Martin, Lefrancq & Sauvageau,
340 2012).

341 Two other case reports described patients with pica, a syndrome characterised by unusual
342 craving for the ingestion of either edible or inedible substances, who ate toilet paper (Chisholm
343 & Martin, 1981; Fisher et al., 2014). The diagnosis of this syndrome is a clinical challenge
344 because this condition might be underreported and is sometimes diagnosed after studying
345 medical complications such as iron deficiency and gastrointestinal bleeding (Fisher et al., 2014).

346 In other cases, biochemical deficiencies need to be studied because hypozincaemia might play a
347 role in the ingestion of toilet paper (Chisholm & Martin, 1981).

348 All six case reports are described in Table 2. The quality of the studies assessed with the CARE
349 guidelines (Table 2) and the recommendations by Murad et al. (Murad et al., 2018) (Table S1)
350 was good. None of these case reports was related to the COVID-19 pandemic.

351

352 **Realist review**

353 The PubMed search for the four theory-driven mechanisms (M1 to M4, Table 1) included a total
354 of 452 records (M1: 108; M2: 104; M3: 80; M4: 60). After the review by three authors, 92
355 records were selected. Fourteen additional records from grey literature were also included.

356

357 COVID-19 disease is associated with diarrhoea (or polyuria), which contributes to panic buying
358 and toilet paper hoarding (Mechanism #1)

359 Most clinical studies suggest that up to 10% of patients suffering from COVID-19 suffer from
360 diarrhoea (Chen et al., 2020c; Guan et al., 2020; Huang et al., 2020; Jin et al., 2020; Kim et al.,
361 2020; Li et al., 2020b; Liu et al., 2020; Xu et al., 2020b; Zhang et al., 2020b), although some
362 studies reported higher rates, between 15% and 34% (Chen et al., 2020b; Pan et al., 2020; Wang
363 et al., 2020a; Zhao et al., 2020). One study (Lei et al., 2020) comparing the clinical features of
364 patients with COVID-19 in Wuhan and outside Wuhan (Guangzhou, China) reported a greater
365 proportion of diarrhoea in the subsample of patients outside Wuhan (25% vs 2%). Another study
366 suggests that the prevalence of diarrhoea is greater (18.8%) in hospitalised frontline medical
367 workers from Wuhan (Wang et al., 2020b). A recent meta-analysis that included 58 studies with
368 COVID-19 patients with data on the prevalence of diarrhoea reported a pooled prevalence of
369 diarrhoea of 12.5% (95% CI, 9.6–16.0) (Cheung et al., 2020). A similar prevalence (12.9%) was
370 also reported by another meta-analysis including 24 studies (Zhu et al., 2020). Other studies in
371 European countries have found even higher rates of diarrhoea, up to half of patients
372 (Klopfenstein et al., 2020; Lechien et al., 2020).

373 A study exploring the clinical characteristics of COVID-19 patients without or with
374 gastrointestinal symptoms (nausea, vomiting or diarrhoea) suggests that the gastrointestinal
375 expression of symptoms is associated with some risk factors (family clustering in exposure, pre-
376 existing chronic liver disease) and with a more severe/critical type of the disease and higher rates
377 of body temperature $>38.5^{\circ}\text{C}$ (Jin et al., 2020). However, the association between diarrhoea and
378 greater disease severity has not been a well-replicated finding, and meta-analysis suggests that
379 there is no relationship between this gastrointestinal symptom and the severity of the COVID-19
380 disease (Henry et al., 2020). Another study pointed out that 19.4% of COVID-19 patients with
381 gastrointestinal symptoms experienced diarrhoea as their first symptom before the onset of
382 respiratory symptoms (Han et al., 2020).

383 The SARS-CoV-2 protein interacts with human angiotensin-converting enzyme 2 (ACE2)
384 molecules, which are highly expressed in absorptive enterocytes from the ileum and colon
385 (Adhikari et al., 2020; Zhang et al., 2020a). ACE2 is recognised as an important regulator of

386 intestinal inflammation, and it has been hypothesised that this is the causal mechanism of
387 diarrhoea in COVID-19 (Ong, Young & Ong, 2020). The SARS-CoV-2 binding affinity for
388 human ACE2 is significantly stronger (10–20 times greater) than its 2003 SARS-CoV
389 predecessor (D’Amico et al., 2020). Already in February, some authors suggested that faecal-oral
390 transmission of SARS-CoV-2 was possible (Yeo, Kaushal & Yeo, 2020), with later studies
391 confirming the presence of SARS-CoV-2 RNA in stool specimens of approximately 53-66% of
392 patients (Chen et al., 2020a; Xiao et al., 2020), independent of the presence of gastrointestinal
393 symptoms or the severity of illness (Chen et al., 2020a). There have been cases in which the
394 SARS-CoV-2 test was negative in the nasopharyngeal swab test after treatment but the rectal test
395 swab specimens still tested positive (Wei et al., 2020), particularly in paediatric patients (Xu et
396 al., 2020a), suggesting that the rectal swab may be equally as important as the pharyngeal swab
397 (He et al., 2020). Surveillance and adequate disinfection in latrines in areas with severe SARS-
398 CoV-2 infection to avoid fomite transmission have also been recommended by some authors (He
399 et al., 2020), as well as avoiding sharing toilets with families for patients with COVID-19 when
400 discharged to home (Li et al., 2020a). As upper gastrointestinal endoscopy can induce coughing
401 and lower gastrointestinal endoscopy can generate aerosol droplets as air is expelled from
402 patients, preparedness for personal protective equipment in the endoscopy setting has also been
403 recommended (Ong, Young & Ong, 2020; Wong, Lui & Sung, 2020).
404 Previous research has not detected viral RNA in urine specimens (Wang et al., 2020c). We did
405 not find studies reporting a direct effect of SARS-CoV-2 on polyuria. However, it is important to
406 underscore that in patients with diabetes, COVID-19 might induce diabetic ketoacidosis (Li et
407 al., 2020c), which is a cause of polyuria.

408 Finally, no studies about toilet paper usage or hoarding in patients with COVID-19 were found.

409

410 Social cognitive biases and social media as facilitators of toilet paper hoarding (Mechanism #2)

411 Social cognitive biases might contribute to the mimicking of conduct by other people. A
412 particularly pivotal role in socially replicated conduct is the bandwagon effect, which might be
413 defined as a phenomenon where the rate of uptake of beliefs, ideas, fads and trends increases the
414 more that they have already been adopted by others (O’Connor & Clark, 2019). This effect has
415 been applied in politics since the 19th century, with the term “jump on the bandwagon” coined
416 when the circus clown Dan Rice used a bandwagon for the political campaign of future-president
417 Zachary Taylor (Chappelow, 2019). This effect might be used to explain some behaviours, such
418 as buying paper toilet rolls if everyone else is buying them. In fact, toilet paper hoarding is a
419 phenomenon that has been proven to be sensitive to this bandwagon effect in other time periods.
420 For instance, in December 1973, in a time of shortages in the United States due to the OPEC oil
421 embargo, Johnny Carson made a joke during his opening monologue of The Tonight Show about
422 an upcoming toilet paper shortage and triggered a nationwide toilet paper buying spree (Malcom,
423 1974). Moreover, stress-related situations might also be involved (e.g., the oil crisis in 1973 and
424 the COVID-19 pandemic in 2019-2020), as stress is thought to potentiate decision biases along
425 with a shift from deliberative to intuitive thinking (Yu, 2016; Jacob et al., 2017). Information

426 bias during decision making favours considering the benefits of saving and the costs of
427 discarding, which can lead to hoarding behaviour (Steketee & Frost, 2003). As already
428 mentioned, the study by Laato et al. (2020) suggests that exposure to online information might
429 contribute to increased buying behaviour and hoarding during the COVID-19 pandemic. The
430 findings of this study also suggest that the intention to self-isolate was a major reason why
431 people made unusual purchases during COVID-19 (to prepare for isolation and quarantine).
432 People with acute stress disorder report more cognitive biases pertaining to external harm,
433 somatic sensations and social events (Smith & Bryant, 2000), suggesting that stress moderates
434 reasoning capability. Socially anxious people are more prone to interpret emotionally ambiguous
435 situations as threatening or negative, also known as interpretation bias, which is involved in the
436 maintenance of anxiety and stress reactivity (Badra et al., 2017; Van Bockstaele et al., 2019).
437 Some authors have suggested that people with elevated negative affectivity and social inhibition,
438 also known as type D personality (Denollet, 2005), might perceive greater threat and report
439 stronger feelings of distress during ambiguous situations (Grynberg et al., 2012) and exhibit an
440 increased risk of stress-related cardiovascular events (Denollet et al., 2006). Studies suggest that
441 individuals with high social stress tend towards vigilance with regard to subliminal social threat
442 cues but not subliminal physical threat cues (Helzer, Connor-Smith & Reed, 2009). A general
443 negative cognitive bias when coping with traumatic exposures is considered to be a risk factor
444 for post-traumatic stress disorder (DiGangi et al., 2013). Traumatic life experiences have also
445 been suggested to increase psychosis proneness via cognitive biases (Gawęda et al., 2018), such
446 as jumping to conclusions (“not needing long to reach a conclusion”), belief inflexibility bias
447 (“not needing to consider alternatives when making a decision”), attention to threat bias (“people
448 cannot be trusted”) and external attribution bias (“things go wrong because of other people”).
449 Previous research exploring the response to social stress in a virtual reality environment suggests
450 that there is an additive effect of separate cognitive biases on paranoid responses to social stress,
451 with greater effects via attention to threat bias and external attribution bias (Pot-Kolder et al.,
452 2018). Studies including patients with schizophrenia and acute delusions also indicate that
453 patients under stress show an increased bias of jumping to conclusions (Moritz et al., 2015).
454 Risk communication, defined by the World Health Organization as “the exchange of real-time
455 information, advice and opinions between experts and people facing threats to their health,
456 economic or social well-being”, might lead to hoarding behaviour (Abrams & Greenhawt, 2020).
457 This risk communication has become more relevant in recent years, as social media networks are
458 constantly increasing. Previous studies modelling the propagation of social responses during a
459 disease outbreak (Fast et al., 2015), which include the hoarding of medical supplies, suggest that
460 heightened social responses spread through the population via two mechanisms: 1) when a
461 disease is novel to the region or is perceived as particularly threatening, media influence spreads
462 concern through the population; 2) when communicating with their neighbours, agents are biased
463 towards adopting the opinions of their more concerned neighbours rather than the most calm
464 ones.

465 Another threat to human society is digital misinformation, which has been suggested to be
466 related to the phenomenon called “echo chambers”, leading to diffusion with a bandwagon effect
467 (Törnberg, 2018). Another problem of misinformation is that false news diffuses faster than true
468 news in social networks (Vosoughi, Roy & Aral, 2018). The bandwagon effect does not apply
469 only to negative or threatening news. For instance, during the COVID-19 pandemic, the toilet
470 paper challenge spread over social media and was replicated by thousands of people. This
471 challenge, also known as the “10 Touch Challenge,” was initially proposed by football players
472 who tried to juggle a roll of toilet paper ten times with their feet, similar to how soccer players
473 juggle soccer balls in training (White, 2020). Thousands of people uploaded their personal
474 videos on the internet, which seemed to relieve the negative effects of the lockdown because
475 most people ended their videos with a satisfied smile. Although it is unknown how long this
476 positive psychological effect lasts, this conduct clearly reflects how the bandwagon effect
477 contributed to the inadequate use of toilet paper during the COVID-19 pandemic.

478

479 Stress worsens mental health and toilet paper hoarding (Mechanism #3)

480 Stress promotes the secretion of hormones (e.g., glucocorticoids, catecholamines) that are
481 adaptive in the short term but that might promote pathophysiological processes over longer time
482 periods, when they are secreted in excess or are dysregulated either by not being produced in
483 sufficient amounts during periods of challenge or change or by not being turned off efficiently
484 after the challenge (McEwen, 2001). Bruce McEwen coined the term allostatic load to define
485 “the wear and tear on the body” as a result of the accumulation of chronic stress (McEwen,
486 1998). This model might be applied to most mental illnesses, including mood disorders
487 (McEwen, 2003), psychotic disorders (Nugent et al., 2015) and anxiety disorders (Nolte et al.,
488 2011).

489 Stressful and traumatic life events might trigger the onset of hoarding disorder, particularly for
490 cases with a later onset (Tolin et al., 2010; Landau et al., 2011). Stress, mainly changes in
491 relationships and interpersonal violence, are also associated with an exacerbation of hoarding
492 behaviour (Tolin et al., 2010). Other studies point out that early life stress with insecure
493 attachment (Danet & Secouet, 2018; Crone et al., 2019) or low parental emotional warmth
494 (Alonso et al., 2004) might play a role in the pathogenesis of hoarding behaviours. Traumatic life
495 events are associated with a greater severity of hoarding symptoms, particularly in the clutter
496 factor of compulsive hoarding (but not in the difficulty of discarding or acquisition) (Cromer,
497 Schmidt & Murphy, 2007). It has been suggested that the coexistence of traumatic experiences
498 and inattention and hyperactivity symptoms could contribute to the difficulties of clutter and
499 organisation reported by hoarders (Hartl et al., 2005). However, other experimental studies that
500 have tested whether stress influences saving and acquiring behavioural tendencies in young
501 adults (Shaw & Timpano, 2016) have yielded unexpected results: participants in the stress
502 condition saved and acquired fewer items than those in the control condition. As discussed by the
503 authors of the previous study (Shaw & Timpano, 2016), the laboratory stressor may not have
504 been strong enough to increase saving and acquiring behavioural tendencies, and there is a need

505 to conduct studies exploring the effects of acute stressors that are more similar to real-life
506 stressors experienced by individuals with hoarding (such as interpersonal conflict).
507 Intolerance to uncertainty has been proposed as a risk factor for hoarding behaviour (Wheaton et
508 al., 2016). Interestingly, recent studies exploring the role of intolerance to uncertainty in mental
509 well-being associated with the COVID-19 pandemic have reported that the combination of
510 rumination and fear of COVID-19 mediates the association between intolerance to uncertainty
511 and mental well-being (Satici et al., 2020). Intolerance to uncertainty is also a predictor of the
512 severity of hoarding symptoms in people with hoarding disorder (Worden et al., 2019). Many of
513 the recommended measures during the COVID-19 pandemic, such as washing and prevention of
514 contamination as well as the quarantine and nationwide lockdown, are thought to worsen
515 symptoms of patients with OCD or hoarding behaviours (Banerjee, 2020). Recent preliminary
516 studies suggest that OCD patients experienced worsened symptoms, particularly contamination
517 obsessions, during the COVID-19 pandemic (Davide et al., 2020).

518 Personality traits are also important moderators of the response to stressful situations,
519 particularly neuroticism, which appears to play a prominent role in the stress process (De Jong,
520 Van Sonderen & Emmelkamp, 1999). People with high neuroticism report more exposure to
521 stressors (Bolger & Schilling, 1991), higher perceived stress (Ebstrup et al., 2011; Kim et al.,
522 2016) and more inadequate coping strategies (Connor-Smith & Flachsbart, 2007). People with
523 high neuroticism are also at greater risk for major depression and more sensitive to the
524 depressogenic effects of adversity resulting from exposure to stressful life events (Kendler, Kuhn
525 & Prescott, 2004). Neuroticism has also been associated with hoarding obsessions and
526 compulsions in a study that assessed personality with the NEO Personality Inventory–Revised
527 (LaSalle-Ricci et al., 2006). In this later study, hoarding was negatively correlated with
528 conscientiousness.

529 Regarding the COVID-19 pandemic, there are 4 studies that have analysed the role of personality
530 traits in toilet paper stockpiling. The first study by Garbe et al. (Garbe, Rau & Toppe, 2020),
531 already mentioned in the Results section of the systematic review, reported that
532 conscientiousness was associated with toilet paper stockpiling, although emotionality had an
533 indirect effect on stockpiling by means of the threat of COVID-19. Another unpublished study
534 by Columbus (2020) conducted a survey in two samples of United Kingdom (UK) residents and
535 considered the stockpiling of foods or supplies. Approximately 36% (sample 1) to 40% (sample
536 2) of participants reported having bought more food or supplies than they usually did during the
537 preceding two weeks in response to the COVID-19 pandemic. Honesty-humility showed a
538 negative association with past stockpiling (sample 1) and a positive association with intentions to
539 refrain from stockpiling in the future (sample 2). The association between this personality
540 dimension and stockpiling was not mediated by beliefs about the shopping behaviour of others.
541 However, other studies suggest that viewing others experiencing stress creates a “contagious”
542 physiological stress response, with faster responses in people with high dispositional levels of
543 empathy (Dimitroff et al., 2017). A recent study (Zettler et al., 2020) explored the relationship
544 between 9 personality factors (including HEXACO and Big Five personality traits) and hoarding

545 behaviour during the COVID-19 pandemic in five independent samples from two Western
546 European countries (overall sample: N= 10.702). In this study, honesty-humility and
547 agreeableness personality traits were negatively associated with hoarding behaviour.
548 Another study (Bentall et al., 2020) explored over-purchasing using data collected in the early
549 stages of the COVID-19 pandemic from two large population internet surveys in the UK and the
550 Republic of Ireland. People did not over-purchase toilet paper more than other common supplies
551 (e.g., tinned food or dried foods). However, this study did not specifically explore psychological
552 determinants of toilet paper hoarding or toilet paper over-purchasing when compared to other
553 items. Over-purchasing or hoarding was found to be positively associated with household
554 income, the presence of children at home, depression, anxiety, and mistrust of others or paranoia.
555 Regarding personality traits, conscientiousness was negatively associated with over-purchasing
556 in both samples. In the Irish sample, openness was also negatively associated with over-
557 purchasing in the Irish sample. In the UK sample, extraversion was associated with over-
558 purchasing, whereas neuroticism was negatively associated with over-purchasing. The variables
559 were found to predict approximately 34-36% of the variance of the model in the Republic of
560 Ireland and the UK.

561 One study (Bai, 2020) using two datasets from the UK (cross-sectional) and the United States
562 (longitudinal) tested whether people who endorse conspiracy theories may be particularly likely
563 to engage in panic buying behaviours during the COVID-19 pandemic. The study found a
564 positive relationship between conspiracy theory endorsement and stockpiling behaviour in both
565 samples. In the US sample, believing that COVID-19 is a real threat was another predictor of
566 stockpiling. Longitudinal analyses suggested that conspiracy theory endorsement was a predictor
567 of stockpiling behaviour in the future, even after controlling for self-reported baseline
568 stockpiling behaviours.

569 Psychoanalytical explanations for the hoarding of toilet paper might be formulated, such as a
570 form of regression to the anal stage allowing our ego to feel in control of an uncontrollable
571 situation (COVID-19 pandemic) (Anghelou, 2020; Wood, 2020). As suggested by Freud, the
572 second stage of psychosexual development is the anal stage (typically occurring during the 2nd
573 year of life), in which the child's interest and sexual pleasure are focused on the expulsion and
574 retention of faeces and the sadistic instinct is linked to the desire to both possess and destroy the
575 object (American Psychological Association, 2020). Some authors (Güzel, 2020) think that panic
576 and restlessness over toilet paper was a response to political failure and that toilet panic hoarding
577 might be understood as a crude solution of the overwhelmed and fragmented subject in the
578 absence of a symbol of authority. Psychoanalytic theories also suggest that a regression to the
579 anal phase might occur in people with hoarding disorder, particularly when a traumatic or
580 emotionally distressing event happens (Camps & Bigot, 2019).

581

582 Cultural aspects moderate the relationship between the COVID-19 pandemic and toilet paper
583 hoarding (Mechanism #4)

584 Some studies have explored whether hoarding disorder features differ across distinct cultural
585 settings. A study that included patients with hoarding disorder from the United Kingdom, Spain,
586 Japan and Brazil (Nordsletten et al., 2018) indicates that the severity and core features of
587 hoarding disorder as well as the cognitions and behaviours commonly associated with this
588 condition are largely stable across cultures. One study comparing symptoms from the hoarding
589 dimension in patients with OCD from China, the USA and Brazil reported a lower proportion of
590 hoarding symptoms in the sample of patients from China (Li et al., 2009). However, another
591 study found that hoarding disorder in East Asia is relatively common and symptomatically
592 similar to that reported in Western countries (Wang et al., 2016).

593 Other studies have explored potential cultural differences in cognitive biases. In a study that
594 examined the relationship between interpretation bias and social anxiety among Chinese
595 adolescents, the results were similar to those found in Western samples (Yu et al., 2019).

596 Although studies have not addressed whether there are differences in the social response to the
597 COVID-19 pandemic by distinct countries or cultures, an indirect way to approach this question
598 is to explore Google trend topics. In the Google trend topics by country for the word “toilet
599 paper”, Australia was the leading country (score of 100), followed by the USA (score of 74) and
600 Canada (score of 42). The trend in the use of the search term “toilet paper” on Google was
601 similar for these three countries and the United Kingdom (Figure 2, A-D), although a different
602 pattern was observed for India (Figure 2E), another country in which English is an official
603 language. As shown in Figure 2, most countries had a peak in March 2020, which coincides with
604 the COVID-19 outbreaks in different countries and the implementation of lockdowns. The
605 massive search for “toilet paper” decreased in a few weeks to previous levels. If we compare the
606 Google search trends for “toilet paper” and “COVID”, in most countries, the “COVID” term was
607 always ranked above “toilet paper” in search interest (Figure S1), with the exception of
608 Australia, such that in the first week of March, the interest in “toilet paper” was 20, clearly above
609 interest in the term “COVID” (5).

610 In a previous study that explored panic buying of toilet paper (Keane & Neal, 2020), an index of
611 panic during the COVID-19 pandemic was created considering five terms: toilet paper, panic
612 buying, hoarding, panic, and supermarket. For non-English-speaking countries, these terms were
613 translated. Countries were grouped into three regions (Europe and North America; Asia
614 [including Oceania]; and the rest of the world). Keane and Neal (Keane & Neal, 2020) found
615 significant heterogeneity between regions in the timing and severity of panic between January
616 and April 2020. They also compared the peak panic indexes between countries: Italy (panic
617 index of 0.15 on 22/3/2020, following the national lockdown on 20/3/2020); France (panic index
618 of 0.083 on 16/3/2020, the same day of the announcement of their nationwide lockdown); United
619 Kingdom (panic index of 0.18 on 22/3/2020, occurring in the same week of the announcement of
620 internal restrictions, including school closings and restrictions on gatherings and movement); and
621 Australia (panic index of 0.79 on 4/3/2020; it was the country with the greatest speed of panic
622 spread [as the panic index was 0.08 two days before, on 2/3/2020]). As there were no important
623 policy announcements in Australia by this time (restrictions on gatherings were announced on

624 13/3/2020), it is difficult to explain this massive spike with these factors. The authors of the last
625 study concluded that their model could not explain this panic pattern in Australia. Other
626 countries with massive spikes that could not be easily explained were Japan, Taiwan and
627 Singapore. The study of Keane and Neal suggested that internal movement restrictions generate
628 considerable consumer panic in the short term, but the effect largely vanishes after a week to ten
629 days. Moreover, they also found a response of consumer panic to announcements of internal
630 movement restrictions in foreign countries.

631 A cultural aspect that is important to consider is the use of toilet paper by different countries.
632 Despite the global reduction in open defecation in the last two decades, which might be defined
633 as the lack of use of toilet facilities for defecation, there is still a substantial worldwide
634 proportion of people from rural areas in less economically developed countries who engage in
635 open defecation. For instance, World Bank data suggest that the prevalence of open defecation in
636 rural areas worldwide was 37.1% in 2000, with a reduction of up to 18.3% in 2017 (World Bank
637 Group, 2020a). This information points to possible differences in the use of toilet paper and
638 likely hoarding behaviour aiming at conserving this item in rural areas when compared to urban
639 areas, as only 1.5% of the population of urban areas continues to engage in open defecation
640 (World Bank Group, 2020b).

641 Toilet paper consumption differs by country. The estimated annual per capita toilet paper
642 consumption in selected countries in 2018 (obtained from Statista Consumer Market Outlook)
643 (Armstrong, 2020) describes the USA as the leading country (141 rolls and 12.7 kg), followed by
644 Germany (134 rolls and 12.1 kg) and the UK (127 rolls and 11.4 kg). There might also be
645 differences in cleaning habits between people from different countries. For instance, data from a
646 WIN/Gallup International survey conducted in 2015 suggest that only 50% of people in the
647 Netherlands wash their hands with soap and water after using the toilet, compared to 96% of
648 people in Bosnia and Herzegovina (Marian, 2015).

649

650

651 **Discussion**

652 Our study aimed to explore the potential contribution of the COVID-19 pandemic to toilet paper
653 hoarding. Our systematic review highlights the scarcity of studies addressing this important
654 topic, and we identified very little published data. We want to highlight the study by Garbe et al.
655 (Garbe, Rau & Toppe, 2020) as being unique because they added empirical data on the influence
656 of the perceived threat of COVID-19 and personality traits (mainly conscientiousness) on several
657 behavioural aspects related to toilet paper shopping and stockpiling. Other studies were focused
658 on the hoarding of supplies (Columbus; Oosterhoff & Palmer, 2020), and they were not
659 specifically focused on toilet paper hoarding, such as the study by Garbe et al. (Garbe, Rau &
660 Toppe, 2020). The secondary outcome of our systematic review focused on mental health, and
661 the pathological use of toilet paper also underscores that this is an under-researched topic, as we
662 could identify only six case reports regarding OCD, suicide, homicide or pica, although the

663 quality of the case reports was relatively good. The methodology of a realist review allowed the
664 study of potential mechanisms contributing to toilet paper hoarding in the COVID-19 pandemic.

665

666 **Potential mechanisms relating the COVID-19 pandemic to toilet paper hoarding**

667 Although the authors of a systematic review on gastrointestinal symptoms in COVID-19 (Miri et
668 al., 2020) suggested that the coexistence of diarrhoea could explain the coronavirus panic buying
669 of toilet rolls, this hypothesis has not been adequately tested in the literature. Moreover, the
670 presence of diarrhoea or the prolonged dissemination of SARS-CoV-2 in the faeces were lesser-
671 known characteristics of the disease at the beginning of the outbreak, when people were buying
672 and hoarding toilet paper. Indeed, the knowledge that there might be faecal-oral transmission of
673 SARS-CoV-2 might induce some people to increase the use of toilet paper, but it does not seem
674 to be the main mechanism explaining the global shopping frenzy at supermarkets. The relatively
675 low proportion of diarrhoea (approximately 12-13%) found in people with COVID-19 infection
676 does not seem to justify the global trends in shopping for toilet paper. Moreover, shopping for
677 and hoarding of toilet paper appeared to be more intense in the first weeks following the
678 COVID-19 outbreak all around the world, with a reduction in the following weeks. This
679 generalised behaviour in stores seems to mimic the Google trend surge on the internet for the
680 word “toilet paper” during March 2020 and was amplified by the national lockdowns in most but
681 not all (e.g., Australia) countries (Keane & Neal, 2020).

682 The mechanism linking social cognitive biases seems to contribute to hoarding behaviour more
683 clearly than the gastrointestinal mechanism. The bandwagon effect is likely the most replicated
684 bias in different countries, as this effect has been previously found to be associated with toilet
685 paper buying (Malcom, 1974). The progressive increase in social networks also seems to have
686 contributed to the fast and worldwide expansion of toilet paper hoarding due to this cognitive
687 bias, with this behaviour being replicated in many countries. Other negative affect and
688 interpretation biases might be linked to intolerance to uncertainty, a clinical characteristic that
689 has been associated with hoarding behaviour (Wheaton et al., 2016). These biases might be even
690 more important given the uncertainty of the COVID-19 situation (Koffman et al., 2020), as the
691 SARS-CoV-2 virus is a new virus with much information to be discovered. Interestingly, the
692 intolerance of uncertainty was associated with poorer mental well-being mediated by both the
693 fear of COVID-19 and rumination (Satici et al., 2020).

694 Another question to be resolved is whether risk factors for toilet paper hoarding during the
695 COVID-19 pandemic are shared with other hoarding behaviours. In this sense, one study pointed
696 out that conscientiousness is a personality trait linked to toilet paper stockpiling during the
697 COVID-19 pandemic (Garbe, Rau & Toppe, 2020), whereas other studies including clinical
698 samples of patients with hoarding symptoms found an opposite result (lower conscientiousness
699 associated with hoarding symptoms) (LaSalle-Ricci et al., 2006). The different roles of
700 conscientiousness in patients with hoarding symptoms and healthy people who hoarded toilet
701 paper during the COVID-19 pandemic is an interesting finding that merits some discussion.
702 Conscientiousness is a personality trait that implies being more efficient and organised, showing

703 self-discipline that involves planned behaviour (Costa, McCrae & Dye, 1991). This personality
704 trait fits well with the idea that healthy people under a stressful situation (e.g., COVID-19
705 pandemic) might decide to buy and hoard toilet paper, particularly when news points to the
706 possibility of a shortage of toilet paper (Schrotenboer, 2020). Although some studies have related
707 conscientiousness with OCD (Rector et al., 2002; Inchausti, Delgado & Prieto, 2015), other
708 studies have found lower conscientiousness in OCD patients than in healthy controls (Hwang et
709 al., 2012). Moreover, other studies suggest that there might exist differences based on the OCD
710 phenotype: higher conscientiousness in comorbid tic-related OCD (Nestadt et al., 2009) and
711 lower conscientiousness in a comorbid affective-related class (Nestadt et al., 2009) or with the
712 presence of hoarding symptoms (LaSalle-Ricci et al., 2006; Samuels et al., 2008; Boerema et al.,
713 2019). The different associations between conscientiousness and hoarding behaviour in non-
714 clinical (higher conscientiousness) and clinical populations (low conscientiousness) is an
715 intriguing finding, as the non-clinical study included people recruited during the COVID-19
716 pandemic (Garbe, Rau & Toppe, 2020), whereas the clinical studies included patients with OCD
717 (LaSalle-Ricci et al., 2006; Samuels et al., 2008; Boerema et al., 2019). Two studies found a
718 negative association between honesty-humility and hoarding food and supplies (Columbus,
719 2020; Zettler et al., 2020). Although no previous studies have explored honesty-humility
720 personality traits in clinical samples of patients with hoarding disorder, this personality trait is
721 associated with trustworthiness (Thielmann & Hilbig, 2015) and cooperation with others. People
722 with hoarding symptoms show increased feelings of hostility in response to social exclusion
723 (Mathes et al., 2019); therefore, it could be hypothesised that hoarders might have a reduced
724 tendency to cooperate with others. It is notable that the two studies reporting associations
725 between honesty-humility and hoarding behaviour during the COVID-19 pandemic (Columbus,
726 2020; Zettler et al., 2020) did not differentiate the subtype of stockpiled items when exploring
727 the contribution of personality factors. In the study by Garbe et al. (2020), which was focused on
728 toilet paper, honesty-humility was not associated with toilet paper stockpiling.

729 It is possible that hoarding of toilet paper is a distinct phenotype compared with hoarding other
730 items, at least in terms of neurobiological/psychological pathophysiological pathways. This
731 important question has yet to be answered, as studies focused on toilet paper hoarding are scarce.
732 Future studies might examine whether personality traits linked to hoarding differ based on the
733 subtype of hoarded items. Although speculative, it could be that toilet paper hoarding is a distinct
734 subtype of hoarding disorder. To date, no definitive conclusions can be drawn, and more
735 research needs to address this issue before assuming a different subtype of hoarding disorder or
736 even considering the inclusion of a specifier for toilet paper hoarding in future diagnostic
737 classifications (e.g., DSM-6). Another limitation of previous research on toilet paper hoarding
738 during the COVID-19 pandemic is that most of the data come from surveys without the
739 administration of diagnostic interviews by a psychiatrist or a clinical psychologist. Therefore, it
740 is important to conduct clinical studies in the future to scrutinize the potential boundaries
741 between mental illnesses and non-psychiatric conditions in the research of toilet paper hoarding.
742 Although the diagnosis of a mental illness might require dysfunction criteria, the study of the

743 boundaries of psychiatric illnesses may not be resolved until there is a detailed understanding of
744 the pathophysiology of the disorders (Kendell & Jablensky, 2003).

745 Future studies also need to better address potential cultural differences that could explain some
746 differences in toilet paper hoarding between countries. An intriguing question is why Australians
747 were the leaders in panic buying. Tim Neal, who participated in a study about panic buying
748 during the COVID-19 pandemic (Keane & Neal, 2020), pointed out that the Australian media's
749 coverage of hoarding could have contributed to the world-leading levels of panic (Zhou, 2020).
750 Other Asian countries, such as Japan, Taiwan and Singapore, that also had massive spikes that
751 could not be easily explained were found in the model developed by Keane and Neal (Keane &
752 Neal, 2020). Shocking news from Asian countries was also reported early in the COVID
753 pandemic, including an armed robbery of toilet paper in Hong Kong (Ho-Him, 2020) or the
754 chaining of toilet paper rolls in public toilets in Japan (Acharya, 2020). Some authors have
755 suggested that the dense, close-knit networks of some countries (e.g., Singapore) make people
756 more prone to adopt the fears and behaviours of the people around them (Bouffanais, 2020).

757

758 **Managing toilet paper hoarding: a proposed algorithm from the CATOTIM group**

759 The management of potential cases of toilet paper hoarding is a challenge for the clinician. The
760 differential diagnosis of a patient with hoarding symptoms is quite complex because hoarding
761 symptoms might be present in different psychiatric and neurological conditions (Pertusa et al.,
762 2010) and because patients with hoarding disorder often underreport specific symptoms
763 (DiMauro et al., 2013). Recent epidemiological studies indicate that the prevalence of hoarding
764 disorder in the general population is 2.5% (confidence interval: 1.7-3.6%), with similar
765 prevalence rates for both males and females (Postlethwaite, Kellett & Mataix-Cols, 2019). We
766 have tried to integrate the main findings of our review and the personal expertise of the members
767 of the Catalan Toilet Tissue Research Group in Mental Health (CATOTIM) that participated in
768 this study in a proposed algorithm that is described in Figure 3. A validation study for this
769 algorithm has not been included; therefore, our pilot algorithm for managing toilet paper
770 hoarding should be considered a theoretical proposal. The generation of the algorithm was a
771 dynamic process. Successive versions of the algorithm were created taking into account the
772 findings of the systematic and realist reviews and the comments from all CATOTIM members.
773 As shown in Figure 3, the first key question is to know whether there is an accumulation
774 (hoarding) of toilet paper. For those cases with evident toilet paper hoarding, psychopathological
775 assessment needs to first detect potential confusion or cognitive problems (attention deficits,
776 memory loss). In that case, it is important to eliminate the possibility of neurological syndromes
777 such as dementia that have been reported to be associated with hoarding symptoms in
778 approximately 23-29% of cases (Hwang et al., 1998; Mitchell et al., 2019). Patients suffering
779 from delirium might have complex stereotyped movements and, rarely, the mimicking of a work
780 pattern (occupational delirium) (Burns, Gallagley & Byrne, 2004). In these situations, it is
781 important to disregard intercurrent medical processes, and it might be necessary to perform blood
782 and urine tests, CT or MRI brain scans, substance use studies, and/or cerebrospinal fluid analyses

783 (in cases with fever). In those patients accumulating toilet paper who show amnesia of the
784 situation and alterations in personal identity, dissociative disorders including post-traumatic
785 stress disorder need to be considered. For this reason, inquiry about potential toilet-related
786 traumatic events may shed light on this diagnosis. In oriented patients, the presence of specific
787 symptoms might lead to specific diagnoses: auditory hallucinations in patients with
788 schizophrenia or schizoaffective disorders and specific delusions in patients with non-affective
789 (e.g., schizophrenia) or affective (bipolar disorder, psychotic depression) psychoses. For
790 instance, a patient suffering from major depression with psychotic features might hoard paper if
791 there are nihilistic or catastrophic delusional ideas (e.g., the belief that bad things are about to
792 happen, feelings of being rotten) (Rothschild, 2013).

793 In some cases, it is possible that people hoard paper to give it to others. In cases when there is a
794 long-standing need for the person to be taken care of and a fear of being abandoned or separated
795 from close individuals, the possibility of a dependent personality disorder needs to be
796 considered. People with bipolar disorder with hypomanic symptoms might also hoard paper for
797 making gifts to others, although the presence of a euphoric mood could also guide the diagnosis.
798 A particularly important condition to be considered is OCD. Initially, hoarding symptoms were
799 thought to be a feature of OCD, but in the last DSM-5, a distinct entity for compulsive hoarding
800 was included. It is critical to explore other obsessive-compulsive symptoms (cleaning obsessions
801 and washing compulsions, sexual/religious obsessions, aggressive obsessions with checking
802 compulsions, symmetry obsessions with ordering compulsions) because their existence can guide
803 the diagnosis to OCD when compared with a primary hoarding disorder without obsessive-
804 compulsive symptoms (Pertusa et al., 2008). Notably, hoarding symptoms might be present in
805 people with high neuroticism, particularly if they suffer from generalised anxiety disorder (Tolin
806 et al., 2011) or obsessive-compulsive personality disorder (OCPD) (Mataix-Cols et al., 2010). If
807 hoarding symptoms appear in people with social isolation and restricted interests, autism
808 disorders and specific personality disorders (schizoid [indifference to social relationships, with a
809 limited range of emotional expression and experience] and avoidant [feelings of extreme social
810 inhibition, inadequacy, and sensitivity to negative criticism and rejection]) also need to be
811 considered. In autism, hoarding symptoms are common (approximately 25% of cases) and are
812 associated with internalizing and anxiety/depressive symptoms, externalizing behaviour, and
813 attention problems (Storch et al., 2016).

814 In cases in which people have been hoarding for reselling toilet paper, antisocial personality
815 traits could be driving the hoarding. There have been documented cases of people hoarding up to
816 4800 toilet paper rolls to resell them on eBay at a greater cost (Brook, 2020). This conduct
817 during a pandemic shows some of the characteristics of an antisocial personality disorder (Black,
818 2015): disregard for right or wrong, deceit for exploitation of others, disrespect of others, and
819 lack of empathy for others.

820 If pathological conditions are not clearly found, as already mentioned, it is important to consider
821 the contribution of social cognitive biases (e.g., bandwagon effect) for inducing hoarding
822 symptoms in non-clinical populations.

823 Sometimes there is excessive buying of toilet paper secondary to excessive use without hoarding
824 behaviour. Clinicians need to consider in these cases the potential medical causes for either
825 diarrhoea or polyuria, with specific tests depending upon the reported symptoms. As already
826 mentioned, in rare conditions, people might eat toilet paper secondary to pica (Chisholm &
827 Martin, 1981; Fisher et al., 2014). In cases with pica, if hypozincaemia is observed,
828 supplementation with zinc might resolve the abnormal eating behaviour (Chisholm & Martin,
829 1981). An excessive (pathological) use of toilet paper by OCD patients with contamination
830 obsession symptoms needs to be considered. In some cases with resistant OCD and excessive
831 wiping, tACS might be useful (Klimke et al., 2016). People with impulse-control disorders and
832 borderline personality disorder might also use toilet paper in excess due to a lack of inhibition
833 control.

834 Although in some cases there is no apparent hoarding or excessive use of toilet paper, it is
835 important to consider the pathological use of toilet paper due to psychopathological disturbances.
836 In people with bipolar disorder with a manic episode, spending sprees and bizarre gifts might
837 occur. In other cases, there could be surreptitious hoarding that was not easily observed in the
838 first assessment. This could arise in people with psychotic symptoms, particularly if there is
839 suspiciousness (e.g., paranoid personality disorder, psychotic disorders). In a patient with
840 depressive mood, suicidal ideation needs to be explored because toilet paper might be used as a
841 lethal mechanism for committing suicide (Sauvageau & Yesovitch, 2006; Saint-Martin, Bouyssy
842 & O'Byrne, 2007).

843 If there is no apparent psychopathology, the diagnosis might be reconsidered. However, a
844 previous step is to be sure that the individual has not participated in the toilet paper challenge. If
845 this is the case, it is probable that his/her conduct is driven by social cognitive biases (e.g.,
846 bandwagon effect).

847 Finally, it is also important to mention that under unusual circumstances, toilet paper hoarding
848 might be considered rational behaviour. In line with this, Laato et al. (2020) suggest that rational
849 decision-making processes might be affected in ill-defined, ambiguous, and unclear
850 circumstances, such as the period in which the COVID-19 virus spread rapidly in Europe during
851 the first wave (March 2020). As this study points out, the buying and stockpiling of toilet paper
852 might be considered a normal behaviour in some circumstances, such as preparing for self-
853 isolation. In these circumstances, defining pathological hoarding, when compared to excessive
854 stockpiling, can be a difficult task.

855

856 **Clinical and ecological implications**

857 Our study underscores the need to consider the pathological use and hoarding of toilet paper in
858 clinical practice, as this behaviour might have negative consequences for the functioning and
859 quality of life of people with or without serious mental illnesses. It is particularly important to
860 eliminate the possibility of psychiatric disorders that might be associated with toilet paper
861 hoarding and that might require specific treatments. This approach is a challenge for psychiatrists

862 and clinical psychologists who need to consider potential comorbid medical conditions that could
863 also worsen this behaviour.

864 The potential contribution of social media to social cognitive biases (e.g., bandwagon effect) and
865 social-driven panic behaviours underscores the importance of managing news in the media and
866 avoiding disseminating fake news on the internet. To fight this issue, in April 2018, the European
867 Commission and representatives of online platforms, leading social networks, advertisers and the
868 advertising industry agreed on a self-regulatory Code of Practice to address the spread of online
869 disinformation and fake news (European Commission, 2020). Attached to the principles of this
870 Code of Practice is a step for most people using and working with social media in order to avoid
871 the negative psychological consequences of disseminating fake news.

872 Recent updated analysis from the Natural Resources Defense Council (NRDC) (Natural
873 Resources Defense Council, 2020) has reported the climate impacts caused by the “tree to toilet”
874 pipeline destroying the climate-critical Canadian boreal forest. Industry is thought to clear one
875 million acres of boreal forest each year (led by Brazil, Russia and Canada in terms of global
876 intact forest loss) in part to produce pulp that US tissue makers roll into toilet paper (Natural
877 Resources Defense Council, 2020). Environmentalists denounce this, as turning a tree into paper
878 requires more water than turning paper back into fibre, and many brands using tree pulp also use
879 polluting chlorine-based bleach to obtain greater whiteness (Kaufman, 2009). Another problem
880 for the sustainability of the planet is the continuously growing tendency to use toilet paper
881 (Crumbie, 2019). The worldwide revenue for the toilet paper segment from the tissue and
882 hygiene paper sector in 2019 was US\$ 83 billion, and it is expected to increase up to US\$ 100
883 billion by the year 2025 (Statista Consumer Market Outlook, 2020). An NRDC report (Skene,
884 2019) suggests that as the market for tissue grows around the world, recycled products and
885 alternative fibres will be the only way to accommodate increased demand without creating
886 further strain on indigenous peoples, the climate, and biodiversity.
887 For all these reasons, it is important that policy makers consider the potential negative impact of
888 toilet paper hoarding at both the individual and community levels, with potential harmful effects
889 to the planet. Therefore, it is recommended that policy makers develop strategies that promote
890 research on the causes and consequences of toilet paper hoarding.

891

892 **Gaps in the literature and future directions**

893 Although a previous survey (Garbe, Rau & Toppe, 2020) suggested that the prevalence of toilet
894 paper hoarding was 17.2% for North Americans and 13.7% for Europeans, more epidemiological
895 studies are needed to weigh the real prevalence of this hoarding behaviour and to administer
896 diagnostic interviews to eliminating the possibility of hoarding behaviour associated with
897 psychiatric disorders or stress-related “reactive” and “transitional” conduct. Longitudinal studies
898 could also help to explore whether these hoarding behaviours associated with the COVID-19
899 pandemic were only associated with the first COVID-19 outbreak or are repeated in subsequent
900 outbreaks.

901 The psychological and neurobiological underpinnings of toilet paper hoarding are a fascinating
902 field to be explored. Future research might study whether or not the mechanisms that lead to
903 saving toilet paper are shared with other hoarded items. A particularly interesting hypothesis to
904 be tested relies on the contribution of personality traits, given the apparent different role of
905 conscientiousness in toilet paper hoarding during the COVID-19 pandemic (Garbe, Rau &
906 Toppe, 2020) and in hoarding symptoms in people with OCD (LaSalle-Ricci et al., 2006; J.F. et
907 al., 2008). Research on neurobiological determinants might study the contribution of stress-
908 related biomarkers, including hypothalamic-pituitary-adrenal (HPA) axis hormones and
909 cytokines, given the implication of these biomarkers in stress-related pathologies (Soria et al.,
910 2018; Russell & Lightman, 2019). Future studies also might want to address the study of faeces,
911 as gut microbiota has emerged as a key player in the control of the HPA axis, especially during
912 stressful situations caused by real or perceived homeostatic challenges (Foster, Rinaman &
913 Cryan, 2017). Neuroimaging studies might also explore the neural correlates of toilet paper
914 hoarding. Patients with hoarding disorder show higher dorsolateral prefrontal cortex (DLPFC)
915 activation during tests of executive functions than do patients with OCD (Hough et al., 2016).
916 OCD patients with prominent hoarding symptoms have also shown greater activation in the
917 bilateral anterior ventromedial prefrontal cortex (VMPFC) than do patients without hoarding
918 symptoms and healthy controls (An et al., 2009). As previous studies have shown dramatic
919 improvement in anus wiping of an OCD patient after brain stimulation with tACS targeting the
920 DLPFC, future studies might study the role of the prefrontal cortex in the pathogenesis of toilet
921 paper hoarding.

922

923 **Study limitations**

924 The main limitation of our study is the small number of studies included in our systematic
925 review. A meta-analysis could not be performed for this reason, as in the protocol of our
926 systematic review, we aimed to include a minimum of 5 studies with similar effect sizes for
927 conducting a quantitative meta-analytical synthesis. We increased the number of publications
928 with the realist review, and we also included grey literature, but the evidence generated from
929 studies during the COVID-19 pandemic was particularly low. A negative publication bias on
930 toilet paper hoarding is possible, as authors might avoid publishing articles dealing with toilet
931 paper. Along these lines, negative outcomes associated with the pathological use of toilet paper
932 (e.g., suicide cases secondary to toilet paper choking) might also be considered humiliating and
933 be underreported in the scientific literature.

934 Finally, although we have proposed an algorithm for managing toilet paper hoarding or other
935 pathological uses of toilet paper, it is important to emphasize that this algorithm has not been
936 validated. Future studies might improve upon this limitation by testing and validating its
937 application in clinical practice. If our algorithm is validated in future studies, it might be useful
938 for psychiatrists and clinical psychologists who need to manage people with potential toilet paper
939 hoarding behaviours.

940 Although our study has several limitations, it is also the first realist review exploring potential
941 mechanisms that could explain in part the toilet paper hoarding experienced in many countries
942 during the COVID-19 pandemic. Our study allows the identification of gaps in the literature and
943 will help researchers to design and conduct future studies aiming to better understand the causes
944 and consequences of toilet paper hoarding in the general population and in people suffering from
945 mental illnesses.

946

947 **Conclusions**

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

956

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959 (CATOTIM), which is composed of psychiatrists and clinical psychologists interested in the
960 study of the causes and consequences of pathological toilet paper use. All authors are members
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962 Rodríguez, Jesús Cobo, Joaquín Puntí, Josep María Farré and Armand Guàrdia. As people were
963 hoarding toilet paper amid the coronavirus pandemic, this study was driven by the interest in
964 studying potential mechanisms linked to this behaviour that can cause distress to individuals.

965

966 **References**

- 967 Abrams EM, Greenhawt M. 2020. Risk Communication During COVID-19. *Journal of Allergy*
968 *and Clinical Immunology: In Practice* 8: 1791–1794. DOI: 10.1016/j.jaip.2020.04.012.
- 969 Acharya D. 2020. Amid The Coronavirus Outbreak, Public Toilets Chain Toilet Paper Rolls
970 Because People Are Stealing Them Like Crazy. Available at
971 <https://mobygeek.com/features/japan-toilets-chian-toilet-paper-rolls-to-avoid-thieves-12251>
- 972 Adhikari SP, Meng S, Wu YJ, Mao YP, Ye RX, Wang QZ, Sun C, Sylvia S, Rozelle S, Raat H,
973 Zhou H. 2020. Epidemiology, causes, clinical manifestation and diagnosis, prevention and
974 control of coronavirus disease (COVID-19) during the early outbreak period: A scoping review.
975 *Infectious Diseases of Poverty* 9:29. DOI: 10.1186/s40249-020-00646-x.
- 976 Alonso P, M. Menchón J, Mataix-Cols D, Pifarré J, Urretavizcaya M, Crespo JM, Jiménez S,
977 Vallejo G, Vallejo J. 2004. Perceived parental rearing style in obsessive-compulsive disorder:

- 978 Relation to symptom dimensions. *Psychiatry Research* 127:267-278. DOI:
979 10.1016/j.psychres.2001.12.002.
- 980 American Psychological Association. 2020. Anal stage. *APA Dictionary of Psychology*.
981 Available at <https://dictionary.apa.org/anal-stage>
- 982 An SK, Mataix-Cols D, Lawrence NS, Wooderson S, Giampietro V, Speckens A, Brammer MJ,
983 Phillips ML. 2009. To discard or not to discard: The neural basis of hoarding symptoms in
984 obsessive-compulsive disorder. *Molecular Psychiatry* 14:318-331. DOI: 10.1038/sj.mp.4002129.
- 985 Anghelou A. 2020. Why everyone is buying toilet paper and how you can manage this period of
986 isolation due to Coronavirus. Available at [https://www.neweurope.eu/article/why-is-everyone-](https://www.neweurope.eu/article/why-is-everyone-buying-toilet-paper-and-how-can-you-manage-this-period-of-isolation-due-to-the-coronavirus/)
987 [buying-toilet-paper-and-how-can-you-manage-this-period-of-isolation-due-to-the-coronavirus/](https://www.neweurope.eu/article/why-is-everyone-buying-toilet-paper-and-how-can-you-manage-this-period-of-isolation-due-to-the-coronavirus/)
- 988 Armstrong M. 2020. The U.S. Leads the World in Toilet Paper Consumption. Available at
989 <https://www.statista.com/chart/15676/cmo-toilet-paper-consumption/>
- 990 Badra M, Schulze L, Becker ES, Vrijnsen JN, Renneberg B, Zetsche U. 2017. The association
991 between ruminative thinking and negative interpretation bias in social anxiety. *Cognition and*
992 *Emotion* 31:1234-1242. DOI: 10.1080/02699931.2016.1193477.
- 993 Bai, M. (2020). Who Bought All the Toilet Paper? Conspiracy Theorists Are More Likely to
994 Stockpile During the COVID-19 Pandemic. 2020. Retrieved from <https://psyarxiv.com/z2g34/>.
995 DOI: 10.31234/osf.io/z2g34
- 996 Banerjee DD. 2020. The other side of COVID-19: Impact on obsessive compulsive disorder
997 (OCD) and hoarding. *Psychiatry Research* 288: 112966. DOI: 10.1016/j.psychres.2020.112966.
- 998 Berg RC, Nanavati J. 2016. Realist Review: Current Practice and Future Prospects. *Journal of*
999 *Research Practice* 12:1-28.
- 1000 Black DW. 2015. The natural history of antisocial personality disorder. *Canadian Journal of*
1001 *Psychiatry* 60: 309–314. DOI: 10.1177/070674371506000703.
- 1002 Boerema YE, de Boer MM, van Balkom AJLM, Eikelenboom M, Visser HA, van Oppen P.
1003 2019. Obsessive compulsive disorder with and without hoarding symptoms: Characterizing
1004 differences. *Journal of Affective Disorders* 246: 652-658. DOI: 10.1016/j.jad.2018.12.115.
- 1005 Bolger N, Schilling EA. 1991. Personality and the Problems of Everyday Life: The Role of
1006 Neuroticism In Exposure and Reactivity to Daily Stressors. *Journal of Personality* 59: 355-386.
1007 DOI: 10.1111/j.1467-6494.1991.tb00253.x.
- 1008 Bouffanais R. 2020. Hoarding toilet paper: The mystery of such panic buying explained. *The*
1009 *Straits Times*. Available at [https://www.straitstimes.com/opinion/hoarding-toilet-paper-the-](https://www.straitstimes.com/opinion/hoarding-toilet-paper-the-mystery-of-such-panic-buying-explained)
1010 [mystery-of-such-panic-buying-explained](https://www.straitstimes.com/opinion/hoarding-toilet-paper-the-mystery-of-such-panic-buying-explained)
- 1011 Brook B. 2020. Supermarket boss's blunt reply to toilet paper hoarder wanting refund.
1012 *News.com.au*. Available at [https://www.news.com.au/finance/business/retail/supermarket-bosss-](https://www.news.com.au/finance/business/retail/supermarket-bosss-blunt-reply-to-toilet-paper-hoarder-wanting-refund/news-story/985cc7022ce371a71b7d86c3031e2ce5)
1013 [blunt-reply-to-toilet-paper-hoarder-wanting-refund/news-](https://www.news.com.au/finance/business/retail/supermarket-bosss-blunt-reply-to-toilet-paper-hoarder-wanting-refund/news-story/985cc7022ce371a71b7d86c3031e2ce5)
1014 [story/985cc7022ce371a71b7d86c3031e2ce5](https://www.news.com.au/finance/business/retail/supermarket-bosss-blunt-reply-to-toilet-paper-hoarder-wanting-refund/news-story/985cc7022ce371a71b7d86c3031e2ce5)
- 1015 Buchholz K. 2020. Toilet Paper Producers Roll'ing in the Dough. Available at
1016 <https://www.statista.com/chart/21327/rise-in-revenue-toilet-paper-selected-countries/>

- 1017 Bulli F, Melli G, Carraresi C, Stopani E, Pertusa A, Frost RO. 2014. Hoarding behaviour in an
1018 Italian non-clinical sample. *Behavioural and Cognitive Psychotherapy* 42: 297-311. DOI:
1019 10.1017/S1352465812001105.
- 1020 Burns A, Gallagley A, Byrne J. 2004. Delirium. *Journal of Neurology, Neurosurgery and*
1021 *Psychiatry* 75: 362-367. DOI: 10.1136/jnnp.2003.023366.
- 1022 Camps FD, Bigot J Le. 2019. A psychoanalytical approach to diogenes syndrome.
1023 *Psychoanalytic Review* 106: 207-223. DOI: 10.1521/prev.2019.106.3.207.
- 1024 Chappelow J. 2019. Bandwagon effect. Available at
1025 <https://www.investopedia.com/terms/b/bandwagon-effect.asp>
- 1026 Chen N, Zhou M, Dong X, Qu J, Gong F, Han Y, Qiu Y, Wang J, Liu Y, Wei Y, Xia J, Yu T,
1027 Zhang X, Zhang L. 2020c. Epidemiological and clinical characteristics of 99 cases of 2019 novel
1028 coronavirus pneumonia in Wuhan, China: a descriptive study. *The Lancet* 395(10223): 507-513
1029 DOI: 10.1016/S0140-6736(20)30211-7.
- 1030 Chen Q, Zheng Z, Zhang C, Zhang X, Wu H, Wang J, Wang S, Zheng C. 2020b. Clinical
1031 characteristics of 145 patients with corona virus disease 2019 (COVID-19) in Taizhou, Zhejiang,
1032 China. *Infection* 48: 543-551. DOI: 10.1007/s15010-020-01432-5.
- 1033 Chen Y, Chen L, Deng Q, Zhang G, Wu K, Ni L, Yang Y, Liu B, Wang W, Wei C, Yang J, Ye
1034 G, Cheng Z. 2020a. The Presence of SARS-CoV-2 RNA in Feces of COVID-19 Patients.
1035 *Journal of medical virology* 92: 833-840. DOI: 10.1002/jmv.25825.
- 1036 Cheung KS, Hung IFN, Chan PPY, Lung KC, Tso E, Liu R, Ng YY, Chu MY, Chung TWH,
1037 Tam AR, Yip CCY, Leung K-H, Fung AY-F, Zhang RR, Lin Y, Cheng HM, Zhang AJX, To
1038 KKW, Chan K-H, Yuen K-Y, Leung WK. 2020. Gastrointestinal Manifestations of SARS-CoV-
1039 2 Infection and Virus Load in Fecal Samples From a Hong Kong Cohort: Systematic Review and
1040 Meta-analysis. *Gastroenterology* 159: 81-95. DOI: 10.1053/j.gastro.2020.03.065.
- 1041 Chisholm JC, Martin HI. 1981. Hypozincemia, ageusia, dysosmia, and toilet tissue pica. *Journal*
1042 *of the National Medical Association* 73:163-164
- 1043 Columbus S. 2020. Who Hoards? Honesty-Humility, beliefs, and prosocial behaviour: A test on
1044 stockpiling during the COVID-19 pandemic. *PsyArXiv Preprints*. Available at
1045 <https://psyarxiv.com/8e62v/>. DOI: 10.31234/osf.io/8e62v.
- 1046 Connor-Smith JK, Flachsbart C. 2007. Relations Between Personality and Coping: A Meta-
1047 Analysis. *Journal of Personality and Social Psychology* 93: 1080-1107. DOI: 10.1037/0022-
1048 3514.93.6.1080.
- 1049 Costa PT, McCrae RR, Dye DA. 1991. Facet scales for agreeableness and conscientiousness: A
1050 revision of tshe NEO personality inventory. *Personality and Individual Differences* 12: 887-898.
1051 DOI: 10.1016/0191-8869(91)90177-D.
- 1052 Cromer KR, Schmidt NB, Murphy DL. 2007. Do traumatic events influence the clinical
1053 expression of compulsive hoarding? *Behaviour Research and Therapy* 45:2581-2592. DOI:
1054 10.1016/j.brat.2007.06.005.
- 1055 Crone C, Kwok C, Chau V, Norberg MM. 2019. Applying attachment theory to indecisiveness in
1056 hoarding disorder. *Psychiatry Research*. 273: 318-324. DOI: 10.1016/j.psychres.2019.01.055.

- 1057 Crumbie A. 2019. Toilet Paper. *Ethical Consumer product guide*. Available at
1058 <https://www.ethicalconsumer.org/home-garden/shopping-guide/toilet-paper>
- 1059 D'Amico F, Baumgart DC, Danese S, Peyrin-Biroulet L. 2020. Diarrhea During COVID-19
1060 Infection: Pathogenesis, Epidemiology, Prevention, and Management. *Clinical Gastroenterology*
1061 *and Hepatology* 18:1663-1672. DOI: 10.1016/j.cgh.2020.04.001.
- 1062 Da Z, Engelberg J, Gao P. 2011. In Search of Attention. *Journal of Finance* 66: 1461-1499. DOI:
1063 10.1111/j.1540-6261.2011.01679.x.
- 1064 Danet M, Secouet D. 2018. Insecure attachment as a factor in hoarding behaviors in a non-
1065 clinical sample of women. *Psychiatry Research* 270: 286-292. DOI:
1066 10.1016/j.psychres.2018.09.053.
- 1067 Davide P, Andrea P, Martina O, Andrea E, Davide D, Mario A. 2020. The impact of the COVID-
1068 19 pandemic on patients with OCD: Effects of contamination symptoms and remission state
1069 before the quarantine in a preliminary naturalistic study. *Psychiatry Research* 291: 113213. DOI:
1070 10.1016/j.psychres.2020.113213.
- 1071 De Jong GM, Van Sonderen E, Emmelkamp PMG. 1999. A comprehensive model of stress. The
1072 roles of experienced stress and neuroticism in explaining the stress-distress relationship.
1073 *Psychotherapy and Psychosomatics* 68: 290-298. DOI: 10.1159/000012346.
- 1074 Denollet J, Pedersen SS, Vrints CJ, Conraads VM. 2006. Usefulness of type D personality in
1075 predicting five-year cardiac events above and beyond concurrent symptoms of stress in patients
1076 with coronary heart disease. *American Journal of Cardiology* 97:970-973. DOI:
1077 10.1016/j.amjcard.2005.10.035.
- 1078 Denollet J. 2005. DS14: Standard assessment of negative affectivity, social inhibition, and type
1079 D personality. *Psychosomatic Medicine* 67:89-97. DOI: 10.1097/01.psy.0000149256.81953.49.
- 1080 DiGangi JA, Gomez D, Mendoza L, Jason LA, Keys CB, Koenen KC. 2013. Pretrauma risk
1081 factors for posttraumatic stress disorder: A systematic review of the literature. *Clinical*
1082 *Psychology Review* 33: 728-744. DOI: 10.1016/j.cpr.2013.05.002.
- 1083 DiMauro J, Tolin DF, Frost RO, Steketee G. 2013. Do people with hoarding disorder under-
1084 report their symptoms? *Journal of Obsessive-Compulsive and Related Disorders* 2:130-136.
1085 DOI: 10.1016/j.jocrd.2013.01.002.
- 1086 Dimitroff SJ, Kardan O, Necka EA, Decety J, Berman MG, Norman GJ. 2017. Physiological
1087 dynamics of stress contagion. *Scientific Reports* 7: 6168. DOI: 10.1038/s41598-017-05811-1.
- 1088 Ebstrup JF, Eplöv LF, Pisinger C, Jørgensen T. 2011. Association between the five factor
1089 personality traits and perceived stress: Is the effect mediated by general self-efficacy? *Anxiety,*
1090 *Stress and Coping* 24: 407-419. DOI: 10.1080/10615806.2010.540012.
- 1091 European Commission. 2020. Code of Practice on Disinformation. Available at
1092 <https://ec.europa.eu/digital-single-market/en/news/code-practice-disinformation>
- 1093 Fast SM, González MC, Wilson JM, Markuzon N. 2015. Modelling the propagation of social
1094 response during a disease outbreak. *Journal of the Royal Society Interface* 12: 20141105. doi:
1095 10.1098/rsif.2014.1105. PMID: 25589575; PMCID: PMC4345477.

- 1096 Fisher C, Laudenslager M, Thapar M, Rothstein K. 2014. A Case of Gastritis in a Patient With
1097 Paper Pica. *American Journal of Gastroenterology* 109: S272. DOI: 10.14309/00000434-
1098 201410002-00922.
- 1099 Foster JA, Rinaman L, Cryan JF. 2017. Stress & the gut-brain axis: Regulation by the
1100 microbiome. *Neurobiology of Stress* 7: 124-13. DOI: 10.1016/j.ynstr.2017.03.001.
- 1101 Garbe L, Rau R, Toppe T. 2020. Influence of perceived threat of Covid-19 and HEXACO
1102 personality traits on toilet paper stockpiling. *PLOS ONE* 15:e0234232. DOI:
1103 10.1371/journal.pone.0234232.
- 1104 Gawęda Ł, Prochwicz K, Adamczyk P, Frydecka D, Misiak B, Kotowicz K, Szczepanowski R,
1105 Florkowski M, Nelson B. 2018. The role of self-disturbances and cognitive biases in the
1106 relationship between traumatic life events and psychosis proneness in a non-clinical sample.
1107 *Schizophrenia Research* 193: 218-224. DOI: 10.1016/j.schres.2017.07.023.
- 1108 Gluth S, Rieskamp J, Büchel C. 2012. Deciding when to decide: time-variant sequential
1109 sampling models explain the emergence of value-based decisions in the human brain. *The*
1110 *Journal of Neuroscience* 32: 10686-10698. DOI: 10.1523/JNEUROSCI.0727-12.2012.
- 1111 Goel S, Hofman JM, Lahaie S, Pennock DM, Watts DJ. 2010. Predicting consumer behavior
1112 with web search. *Proceedings of the National Academy of Sciences of the United States of*
1113 *America* 107:17486-17490. DOI: 10.1073/pnas.1005962107.
- 1114 Greenhalgh T, Schmid MB, Czypionka T, Bassler D, Gruer L. 2020. Face masks for the public
1115 during the covid-19 crisis. *The BMJ* 369:m1435. DOI: 10.1136/bmj.m1435.
- 1116 Grynberg D, Gidron Y, Denollet J, Luminet O. 2012. Evidence for a cognitive bias of
1117 interpretation toward threat in individuals with a Type D personality. *Journal of Behavioral*
1118 *Medicine* 35:95-102. DOI: 10.1007/s10865-011-9351-7.
- 1119 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
1120 G, Yuen KY, Chen R, Tang C, Wang T, Chen P, Xiang J, Li S, Wang JL, Liang Z, Peng Y, Wei
1121 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,
1122 Zhong N. 2020. Clinical characteristics of coronavirus disease 2019 in China. *The New England*
1123 *Journal of Medicine* 382:1708-1720. DOI: 10.1056/NEJMoa2002032.
- 1124 Güzel A. 2020. A brief reflection on losing and finding toilet paper. *Psychodynamic Practice*, 26:
1125 215-220. DOI: 10.1080/14753634.2020.1759290
- 1126 Han C, Duan C, Zhang S, Spiegel B, Shi H, Wang W, Zhang L, Lin R, Liu J, Ding Z, Hou X.
1127 2020. Digestive Symptoms in COVID-19 Patients With Mild Disease Severity: Clinical
1128 Presentation, Stool Viral RNA Testing, and Outcomes. *The American Journal of*
1129 *Gastroenterology* 115: 916-923. DOI: 10.14309/ajg.0000000000000664.
- 1130 Hartl TL, Duffany SR, Allen GJ, Steketee G, Frost RO. 2005. Relationships among compulsive
1131 hoarding, trauma, and attention-deficit/ hyperactivity disorder. *Behaviour Research and Therapy*
1132 43: 269-476. DOI: 10.1016/j.brat.2004.02.002.
- 1133 He Y, Wang Z, Li F, Shi Y. 2020. Public health might be endangered by possible prolonged
1134 discharge of SARS-CoV-2 in stool. *Journal of Infection* 80:e18-e19. DOI:
1135 10.1016/j.jinf.2020.02.031.

- 1136 Helzer EG, Connor-Smith JK, Reed MA. 2009. Traits, states, and attentional gates:
1137 Temperament and threat relevance as predictors of attentional bias to social threat. *Anxiety,*
1138 *Stress and Coping* 22: 57-76. DOI: 10.1080/10615800802272244.
- 1139 Henry BM, de Oliveira MHS, Benoit J, Lippi G. 2020. Gastrointestinal symptoms associated
1140 with severity of coronavirus disease 2019 (COVID-19): a pooled analysis. *Internal and*
1141 *Emergency Medicine* 15: 857-859. DOI: 10.1007/s11739-020-02329-9.
- 1142 Ho-Him C. 2020. Two arrested after armed gang makes run for toilet rolls in HK\$1,600 heist as
1143 coronavirus panic shows no signs of easing. Available at [https://www.scmp.com/news/hong-](https://www.scmp.com/news/hong-kong/law-and-crime/article/3050907/armed-gang-steals-hk1000-toilet-paper-coronavirus)
1144 [kong/law-and-crime/article/3050907/armed-gang-steals-hk1000-toilet-paper-coronavirus](https://www.scmp.com/news/hong-kong/law-and-crime/article/3050907/armed-gang-steals-hk1000-toilet-paper-coronavirus)
- 1145 Hough CM, Luks TL, Lai K, Vigil O, Guillory S, Nongpiur A, Fekri SM, Kupferman E,
1146 Mathalon DH, Mathews CA. 2016. Comparison of brain activation patterns during executive
1147 function tasks in hoarding disorder and non-hoarding OCD. *Psychiatry Research - Neuroimaging*
1148 255:50-59. DOI: 10.1016/j.psychresns.2016.07.007.
- 1149 Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, Zhang L, Fan G, Xu J, Gu X, Cheng Z, Yu T,
1150 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
1151 R, Gao Z, Jin Q, Wang J, Cao B. 2020. Clinical features of patients infected with 2019 novel
1152 coronavirus in Wuhan, China. *The Lancet* 395: 497-506. DOI: 10.1016/S0140-6736(20)30183-5.
- 1153 Hwang JP, Tsai SJ, Yang CH, Liu KM, Lirng JF. 1998. Hoarding behavior in dementia: A
1154 preliminary report. *American Journal of Geriatric Psychiatry* 6: 285-259. DOI:
1155 10.1097/00019442-199800640-00003.
- 1156 Hwang JY, Shin YC, Lim SW, Park HY, Shin NY, Jang JH, Park HY, Kwon JS. 2012.
1157 Multidimensional Comparison of Personality Characteristics of the Big Five Model,
1158 Impulsiveness, and Affect in Pathological Gambling and Obsessive-Compulsive Disorder.
1159 *Journal of Gambling Studies*. 28: 351-362. DOI: 10.1007/s10899-011-9269-6.
- 1160 Inchausti F, Delgado AR, Prieto G. 2015. Obsessive-compulsive disorder and its relationship
1161 with disgust vulnerability and conscientiousness. *Psicothema* 27: 254-260. DOI:
1162 10.7334/psicothema2015.7.
- 1163 Jacob C, Hoffmann V, Olliges E, Haile A, Jacobi B, Steinkopf L, Lanz M, Tschoep M, Meissner
1164 K. 2017. Stress changes how we think – Psychophysiological evidence for the Stress-Induced
1165 Deliberation to Intuition (SIDI)-model. *Psychoneuroendocrinology* 83: 13. DOI:
1166 10.1016/j.psyneuen.2017.07.273.
- 1167 Jin X, Lian JS, Hu JH, Gao J, Zheng L, Zhang YM, Hao SR, Jia HY, Cai H, Zhang XL, Yu GD,
1168 Xu KJ, Wang XY, Gu JQ, Zhang SY, Ye CY, Jin CL, Lu YF, Yu X, Yu XP, Huang JR, Xu KL,
1169 Ni Q, Yu CB, Zhu B, Li YT, Liu J, Zhao H, Zhang X, Yu L, Guo YZ, Su JW, Tao JJ, Lang GJ,
1170 Wu XX, Wu WR, Qv TT, Xiang DR, Yi P, Shi D, Chen Y, Ren Y, Qiu YQ, Li LJ, Sheng J,
1171 Yang Y. 2020. Epidemiological, clinical and virological characteristics of 74 cases of
1172 coronavirus-infected disease 2019 (COVID-19) with gastrointestinal symptoms. *Gut* 69:1002-
1173 1009. DOI: 10.1136/gutjnl-2020-320926.
- 1174 Kaufman L. 2009. Mr. Whipple Left It Out: Soft Is Rough on Forests. *The New York Times*.
1175 Available at <https://www.nytimes.com/2009/02/26/science/earth/26charmin.html>

- 1176 Keane MP, Neal T. 2020. Consumer Panic in the COVID-19 Pandemic. *SSRN Electronic*
1177 *Journal*. DOI: 10.2139/ssrn.3600018.
- 1178 Kendell R, Jablensky A. 2003. Distinguishing between the validity and utility of psychiatric
1179 diagnoses. *American Journal of Psychiatry*. 160: 4-12. DOI: 10.1176/appi.ajp.160.1.4.
- 1180 Kendler KS, Kuhn J, Prescott CA. 2004. The Interrelationship of Neuroticism, Sex, and Stressful
1181 Life Events in the Prediction of Episodes of Major Depression. *American Journal of Psychiatry*
1182 161: 631-636. DOI: 10.1176/appi.ajp.161.4.631.
- 1183 Kim ES, Chin BS, Kang CK, Kim NJ, Kang YM, Choi JP, Oh DH, Kim JH, Koh B, Kim SE,
1184 Yun NR, Lee JH, Kim JY, Kim Y, Bang JH, Song KH, Kim H Bin, Chung K hyun, Oh M don.
1185 2020. Clinical course and outcomes of patients with severe acute respiratory syndrome
1186 coronavirus 2 infection: A preliminary report of the first 28 patients from the korean cohort study
1187 on COVID-19. *Journal of Korean Medical Science* 35: e142. DOI:
1188 10.3346/JKMS.2020.35.E142.
- 1189 Kim SE, Kim HN, Cho J, Kwon MJ, Chang Y, Ryu S, Shin H, Kim HL. 2016. Direct and
1190 indirect effects of five factor personality and gender on depressive symptoms mediated by
1191 perceived stress. *PLoS ONE* 11: e0154140. DOI: 10.1371/journal.pone.0154140.
- 1192 Kirk CP, Rifkin LS. 2020. I'll trade you diamonds for toilet paper: Consumer reacting, coping
1193 and adapting behaviors in the COVID-19 pandemic. *Journal of Business Research* 117: 124-131.
1194 DOI: 10.1016/j.jbusres.2020.05.028.
- 1195 Klimke A, Nitsche MA, Maurer K, Voss U. 2016. Case Report: Successful Treatment of
1196 Therapy-Resistant OCD with Application of Transcranial Alternating Current Stimulation
1197 (tACS). *Brain Stimulation* 9: 463-465. DOI: 10.1016/j.brs.2016.03.005.
- 1198 Klopfenstein T, Kadiane-Oussou NJ, Royer PY, Toko L, Gendrin V, Zayet S. 2020. Diarrhea:
1199 An underestimated symptom in Coronavirus disease 2019. *Clinics and Research in Hepatology*
1200 *and Gastroenterology* 44: 282-283. DOI: 10.1016/j.clinre.2020.04.002.
- 1201 Knoll C. 2020. Panicked Shoppers Empty Shelves as Coronavirus Anxiety Rises. *The New York*
1202 *Times*. Available at [https://www.nytimes.com/2020/03/13/nyregion/coronavirus-panic-](https://www.nytimes.com/2020/03/13/nyregion/coronavirus-panic-buying.html)
1203 [buying.html](https://www.nytimes.com/2020/03/13/nyregion/coronavirus-panic-buying.html)
- 1204 Koffman J, Gross J, Etkind SN, Selman L. 2020. Uncertainty and COVID-19: how are we to
1205 respond? *Journal of the Royal Society of Medicine* 113: 211-216. DOI:
1206 10.1177/0141076820930665.
- 1207 Landau D, Iervolino AC, Pertusa A, Santo S, Singh S, Mataix-Cols D. 2011. Stressful life events
1208 and material deprivation in hoarding disorder. *Journal of Anxiety Disorders* 25: 192-202. DOI:
1209 10.1016/j.janxdis.2010.09.002.
- 1210 LaSalle-Ricci VH, Arnkoff DB, Glass CR, Crawley SA, Ronquillo JG, Murphy DL. 2006. The
1211 hoarding dimension of OCD: Psychological comorbidity and the five-factor personality model.
1212 *Behaviour Research and Therapy* 44: 1503-1512. DOI: 10.1016/j.brat.2005.11.009.
- 1213 Lawrence LM, Ciorciari J, Kyrios M. 2014. Relationships that compulsive buying has with
1214 addiction, obsessive-compulsiveness, hoarding, and depression. *Comprehensive Psychiatry*
1215 55:1137-1145. DOI: 10.1016/j.comppsy.2014.03.005.

- 1216 Lechien JR, Chiesa-Estomba CM, De Siati DR, Horoi M, Le Bon SD, Rodriguez A, Dequanter
1217 D, Blecic S, El Afia F, Distinguin L, Chekkoury-Idrissi Y, Hans S, Delgado IL, Calvo-Henriquez
1218 C, Lavigne P, Falanga C, Barillari MR, Cammaroto G, Khalife M, Leich P, Souchay C, Rossi C,
1219 Journe F, Hsieh J, Edjlali M, Carlier R, Ris L, Lovato A, De Filippis C, Coppee F, Fakhry N,
1220 Ayad T, Saussez S. 2020. Olfactory and gustatory dysfunctions as a clinical presentation of mild-
1221 to-moderate forms of the coronavirus disease (COVID-19): a multicenter European study.
1222 *European Archives of Oto-Rhino-Laryngology* 277: 2251-2261. DOI: 10.1007/s00405-020-
1223 05965-1.
- 1224 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,
1225 Chen D, Gao Z, He JR, Lin BL. 2020. A cross-sectional comparison of epidemiological and
1226 clinical features of patients with coronavirus disease (COVID-19) in Wuhan and outside Wuhan,
1227 China. *Travel Medicine and Infectious Disease*. 35: 101664. DOI: 10.1016/j.tmaid.2020.101664.
- 1228 Leung H. 2020. Knife-Wielding Robbers in Hong Kong Steal 600 Rolls of Toilet Paper Amid
1229 Coronavirus Panic. *Time*. Available at [https://time.com/5785146/hong-kong-toilet-paper-
1230 robbery-coronavirus/](https://time.com/5785146/hong-kong-toilet-paper-robbery-coronavirus/)
- 1231 Lewis L. 2020. Coronavirus forces Japan to rethink its view of toilet roll. *Financial Times*.
1232 Available at <https://www.ft.com/content/397bd2a4-5d35-11ea-b0ab-339c2307bcd4>
- 1233 Li J, Wang X, Chen J, Zuo X, Zhang H, Deng A. 2020c. COVID-19 infection may cause ketosis
1234 and ketoacidosis. *Diabetes, Obesity and Metabolism*. DOI: 10.1111/dom.14057.
- 1235 Li L quan, Huang T, Wang Y qing, Wang Z ping, Liang Y, Huang T bi, Zhang H yun, Sun W,
1236 Wang Y. 2020b. COVID-19 patients' clinical characteristics, discharge rate, and fatality rate of
1237 meta-analysis. *Journal of Medical Virology* 92: 577-583. DOI: 10.1002/jmv.25757.
- 1238 Li XY, Dai WJ, Wu SN, Yang XZ, Wang HG. 2020a. The occurrence of diarrhea in COVID-19
1239 patients. *Clinics and Research in Hepatology and Gastroenterology* 44: 284–285. DOI:
1240 10.1016/j.clinre.2020.03.017.
- 1241 Li Y, Marques L, Hinton DE, Wang Y, Xiao ZP. 2009. Symptom dimensions in Chinese patients
1242 with obsessive-compulsive disorder. *CNS Neuroscience and Therapeutics* 15: 276-282. DOI:
1243 10.1111/j.1755-5949.2009.00099.x.
- 1244 Liu K, Fang YY, Deng Y, Liu W, Wang MF, Ma JP, Xiao W, Wang YN, Zhong MH, Li CH, Li
1245 GC, Liu HG. 2020. Clinical characteristics of novel coronavirus cases in tertiary hospitals in
1246 Hubei Province. *Chinese Medical Journal* 133:1025-1031. DOI:
1247 10.1097/CM9.0000000000000744.
- 1248 Malcom AH. 1974. The “shortage” of bathroom tissue: a classic study in rumor. *New York
1249 Times*.
- 1250 Marian J. 2015. Study Reveals Hand-Washing Habits of Europeans. Available at
1251 <https://jakubmarian.com/a-study-reveals-how-many-europeans-wash-their-hands-with-soap/>
1252 Mataix-Cols D, Cullen S, Lange K, Zelaya F, Andrew C, Amaro E, Brammer MJ, Williams SC,
1253 Speckens A, Phillips ML. 2003. Neural correlates of anxiety associated with obsessive-
1254 compulsive symptom dimensions in normal volunteers. *Biol Psychiatry* 53:482-493. DOI:
1255 10.1016/s0006-3223(02)01504-4. PMID: 12644353.

- 1256 Mataix-Cols D, Frost RO, Pertusa A, Clark LA, Saxena S, Leckman JF, Stein DJ, Matsunaga H,
1257 Wilhelm S. 2010. Hoarding disorder: A new diagnosis for DSM-V? *Depression and Anxiety* 27:
1258 556-572. DOI: 10.1002/da.20693.
- 1259 Mathes BM, Kennedy GA, Cogle JR, Schmidt NB. 2019. An examination of the relationship
1260 between hoarding symptoms and hostility. *Journal of Psychiatric Research* 111: 121-127. DOI:
1261 10.1016/j.jpsychires.2019.01.025.
- 1262 McEwen BS. 1998. Stress, adaptation, and disease. Allostasis and allostatic load. *Annals of the*
1263 *New York Academy of Sciences* 840: 33–44. DOI: 10.1111/j.1749-6632.1998.tb09546.x.
- 1264 McEwen BS. 2001. From molecules to mind. Stress, individual differences, and the social
1265 environment. *Annals of the New York Academy of Sciences* 935: 42-9. DOI: 10.1111/j.1749-
1266 6632.2001.tb03469.x.
- 1267 McEwen BS. 2003. Mood disorders and allostatic load. *Biological Psychiatry* 54:200–207. DOI:
1268 10.1016/S0006-3223(03)00177-X.
- 1269 Micalizzi L, Zambrotta NS, Bernstein MH. 2020. Stockpiling in the time of COVID-19. *British*
1270 *Journal of Health Psychology*. DOI: 10.1111/bjhp.12480.
- 1271 Miri SM, Roozbeh F, Omranirad A, Alavian SM. 2020. Panic of Buying Toilet Papers: A
1272 Historical Memory or a Horrible Truth? Systematic Review of Gastrointestinal Manifestations of
1273 COVID-19. *Hepatitis Monthly* 20: e102729. DOI: 10.5812/hepatmon.102729.
- 1274 Mitchell E, Tavares TP, Palaniyappan L, Finger EC. 2019. Hoarding and obsessive–compulsive
1275 behaviours in frontotemporal dementia: Clinical and neuroanatomic associations. *Cortex* 121:
1276 443-453. DOI: 10.1016/j.cortex.2019.09.012.
- 1277 Moher D, Liberati A, Tetzlaff J, Altman DG. 2009. Preferred reporting items for systematic
1278 reviews and meta-analyses: the PRISMA statement. *BMJ* 339:b2535–b2535. DOI:
1279 10.1136/bmj.b2535.
- 1280 Moritz S, Köther U, Hartmann M, Lincoln TM. 2015. Stress is a bad advisor. Stress primes poor
1281 decision making in deluded psychotic patients. *European Archives of Psychiatry and Clinical*
1282 *Neuroscience* 265: 461-469. DOI: 10.1007/s00406-015-0585-1.
- 1283 Murad MH, Sultan S, Haffar S, Bazerbachi F. 2018. Methodological quality and synthesis of
1284 case series and case reports. *Evidence-Based Medicine* 23: 60-63. DOI: 10.1136/bmjebm-2017-
1285 110853.
- 1286 Natural Resources Defense Council. 2020. Toilet Paper and Climate Change: NRDC’s Updated
1287 “Issue With Tissue” Ranks Brands on Sustainability. 2020. Available at
1288 <https://www.nrdc.org/media/2020/200618-20>
- 1289 Nestadt G, Di CZ, Riddle MA, Grados MA, Greenberg BD, Fyer AJ, McCracken JT, Rauch SL,
1290 Murphy DL, Rasmussen SA, Cullen B, Pinto A, Knowles JA, Piacentini J, Pauls DL, Bienvenu
1291 OJ, Wang Y, Liang KY, Samuels JF, Roche KB. 2009. Obsessive-compulsive disorder:
1292 Subclassification based on co-morbidity. *Psychological Medicine* 39: 1491-1501. DOI:
1293 10.1017/S0033291708004753.

- 1294 Nolte T, Guiney J, Fonagy P, Mayes LC, Luyten P. 2011. Interpersonal stress regulation and the
1295 development of anxiety disorders: An attachment-based developmental framework. *Frontiers in*
1296 *Behavioral Neuroscience* 5: 55. DOI: 10.3389/fnbeh.2011.00055.
- 1297 Nordsletten AE, Fernández de la Cruz L, Aluco E, Alonso P, López-Solà C, Menchón JM,
1298 Nakao T, Kuwano M, Yamada S, Fontenelle LF, Campos-Lima AL, Mataix-Cols D. 2018. A
1299 transcultural study of hoarding disorder: Insights from the United Kingdom, Spain, Japan, and
1300 Brazil. *Transcultural Psychiatry* 55: 261-285 . DOI: 10.1177/1363461518759203.
- 1301 Nordsletten AE, Reichenberg A, Hatch SL, Fernández De La Cruz L, Pertusa A, Hotopf M,
1302 Mataix-Cols D. 2013. Epidemiology of hoarding disorder. *British Journal of Psychiatry* 203:
1303 445-452. DOI: 10.1192/bjp.bp.113.130195.
- 1304 Nugent KL, Chiappelli J, Rowland LM, Hong LE. 2015. Cumulative stress pathophysiology in
1305 schizophrenia as indexed by allostatic load. *Psychoneuroendocrinology* 60:120–129. DOI:
1306 10.1016/j.psyneuen.2015.06.009.
- 1307 O'Connor N, Clark S. 2019. Beware bandwagons! The bandwagon phenomenon in medicine,
1308 psychiatry and management. *Australasian Psychiatry* 27: 603-606. DOI:
1309 10.1177/1039856219848829.
- 1310 Ong J, Young BE, Ong S. 2020. COVID-19 in gastroenterology: A clinical perspective. *Gut* 69:
1311 1144-1145. DOI: 10.1136/gutjnl-2020-321051.
- 1312 Oosterhoff B, Palmer CA. 2020. Attitudes and Psychological Factors Associated With News
1313 Monitoring, Social Distancing, Disinfecting, and Hoarding Behaviors Among US Adolescents
1314 During the Coronavirus Disease 2019 Pandemic. *JAMA Pediatrics* e201876 . DOI:
1315 10.1001/jamapediatrics.2020.1876.
- 1316 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,
1317 Du Y, Li T, Xu G, Hu Q, Tu L. 2020. Clinical characteristics of COVID-19 patients with
1318 digestive symptoms in Hubei, China: A descriptive, cross-sectional, multicenter study. *American*
1319 *Journal of Gastroenterology* 115: 766-773. DOI: 10.14309/ajg.0000000000000620.
- 1320 Pertusa A, Frost RO, Fullana MA, Samuels J, Steketee G, Tolin D, Saxena S, Leckman JF,
1321 Mataix-Cols D. 2010. Refining the diagnostic boundaries of compulsive hoarding: A critical
1322 review. *Clinical Psychology Review* 30: 371-386. DOI: 10.1016/j.cpr.2010.01.007.
- 1323 Pertusa A, Fullana MA, Singh S, Alonso P, Menchón JM, Mataix-Cols D. 2008. Compulsive
1324 hoarding: OCD symptom, distinct clinical syndrome, or both? *American Journal of Psychiatry*
1325 165: 1289-1298. DOI: 10.1176/appi.ajp.2008.07111730.
- 1326 Pidd H. 2020. UK supermarkets ration toilet paper to prevent stockpiling. The Guardian.
1327 Available at [https://www.theguardian.com/world/2020/mar/08/coronavirus-stockpiling-](https://www.theguardian.com/world/2020/mar/08/coronavirus-stockpiling-supermarkets-toilet-paper-hand-gel)
1328 [supermarkets-toilet-paper-hand-gel](https://www.theguardian.com/world/2020/mar/08/coronavirus-stockpiling-supermarkets-toilet-paper-hand-gel)
- 1329 Postlethwaite A, Kellett S, Mataix-Cols D. 2019. Prevalence of Hoarding Disorder: A systematic
1330 review and meta-analysis. *Journal of Affective Disorders* 256: 309-316. DOI:
1331 10.1016/j.jad.2019.06.004.

- 1332 Pot-Kolder R, Veling W, Counotte J, Van Der Gaag M. 2018. Self-reported Cognitive Biases
1333 Moderate the Associations between Social Stress and Paranoid Ideation in a Virtual Reality
1334 Experimental Study. *Schizophrenia Bulletin* 44: 749-756. DOI: 10.1093/schbul/sbx119.
- 1335 Rector NA, Hood K, Richter MA, Michael Bagby R. 2002. Obsessive-compulsive disorder and
1336 the five-factor model of personality: Distinction and overlap with major depressive disorder.
1337 *Behaviour Research and Therapy* 40: 1205-1219. DOI: 10.1016/S0005-7967(02)00024-4.
- 1338 Riley DS, Barber MS, Kienle GS, Aronson JK, von Schoen-Angerer T, Tugwell P, Kiene H,
1339 Helfand M, Altman DG, Sox H, Werthmann PG, Moher D, Rison RA, Shamseer L, Koch CA,
1340 Sun GH, Hanaway P, Sudak NL, Kaszkin-Bettag M, Carpenter JE, Gagnier JJ. 2017. CARE
1341 guidelines for case reports: explanation and elaboration document. *Journal of Clinical*
1342 *Epidemiology* 89: 218-235. DOI: 10.1016/j.jclinepi.2017.04.026.
- 1343 Rothschild AJ. 2013. Challenges in the treatment of major depressive disorder with psychotic
1344 features. *Schizophrenia Bulletin* 39: 787-796. DOI: 10.1093/schbul/sbt046.
- 1345 Russell G, Lightman S. 2019. The human stress response. *Nature Reviews Endocrinology* 15:
1346 525-534. DOI: 10.1038/s41574-019-0228-0.
- 1347 Saint-Martin P, Bouyssy M, O'Byrne P. 2007. An unusual case of suicidal asphyxia by
1348 smothering. *Journal of Forensic and Legal Medicine* 14:39–41. DOI:
1349 10.1016/j.jcfm.2005.11.015.
- 1350 Saint-Martin P, Lefrancq T, Sauvageau A. 2012. Homicidal smothering on toilet paper: A case
1351 report. *Journal of Forensic and Legal Medicine* 19: 234–235. DOI: 10.1016/j.jflm.2011.12.032.
- 1352 Samuels JF, Bienvenu OJ, Pinto A, Murphy DL, Piacentini J, Rauch SL, Fyer AJ, Grados MA,
1353 Greenberg BD, Knowles JA, McCracken JT, Cullen B, Riddle MA, Rasmussen SA, Pauls DL,
1354 Liang KY, Hoehn-Saric R, Pulver AE, Nestadt G. 2008. Sex-specific clinical correlates of
1355 hoarding in obsessive-compulsive disorder. *Behaviour Research and Therapy* 46:1040-1046.
1356 DOI: 10.1016/j.brat.2008.06.005.
- 1357 Samuels JF, Bienvenu OJ, Pinto A, Murphy DL, Piacentini J, Rauch SL, Fyer AJ, Grados MA,
1358 Greenberg BD, Knowles JA, McCracken JT, Cullen B, Riddle MA, Rasmussen SA, Pauls DL,
1359 Liang KY, Hoehn-Saric R, Pulver AE, Nestadt G. 2008. Sex-specific clinical correlates of
1360 hoarding in obsessive-compulsive disorder. *Behaviour Research and Therapy* 46: 1040-1046 .
1361 DOI: 10.1016/j.brat.2008.06.005.
- 1362 Satici B, Saricali M, Satici SA, Griffiths MD. 2020. Intolerance of Uncertainty and Mental
1363 Wellbeing: Serial Mediation by Rumination and Fear of COVID-19. *International Journal of*
1364 *Mental Health and Addiction*. DOI: 10.1007/s11469-020-00305-0.
- 1365 Sauvageau A, Yesovitch R. 2006. Choking on toilet paper: an unusual case of suicide and a
1366 review of the literature on suicide by smothering, strangulation, and choking. *The American*
1367 *Journal of Forensic Medicine and Pathology* 27:173–174. DOI:
1368 10.1097/01.paf.0000203269.97907.a7.
- 1369 Schrotenboer B. 2020. Coronavirus and shopping for supplies: Getting to the bottom of the toilet
1370 paper shortage. *USA Today*. Available at

- 1371 <https://eu.usatoday.com/story/money/2020/04/08/coronavirus-shortage-where-has-all-the-toilet->
1372 [paper-gone/2964143001/](https://eu.usatoday.com/story/money/2020/04/08/coronavirus-shortage-where-has-all-the-toilet-paper-gone/2964143001/)
- 1373 Shaw AM, Timpano KR. 2016. An Experimental Investigation of the Effect of Stress on Saving
1374 and Acquiring Behavioral Tendencies: The Role of Distress Tolerance and Negative Urgency.
1375 *Behavior Therapy* 47: 116-129 . DOI: 10.1016/j.beth.2015.10.003.
- 1376 Sim K, Chua HC, Vieta E, Fernandez G. 2020. The anatomy of panic buying related to the
1377 current COVID-19 pandemic. *Psychiatry Research* 288:113015. DOI:
1378 10.1016/j.psychres.2020.113015.
- 1379 Skene J. 2019. The issue with tissue: how americans are flushing forests down the toilet. *Natural*
1380 *Resources Defense Council (NRDC) Report*. Available at
1381 [https://www.nrdc.org/sites/default/files/issue-tissue-how-americans-are-flushing-forests-down-](https://www.nrdc.org/sites/default/files/issue-tissue-how-americans-are-flushing-forests-down-toilet-report.pdf)
1382 [toilet-report.pdf](https://www.nrdc.org/sites/default/files/issue-tissue-how-americans-are-flushing-forests-down-toilet-report.pdf)
- 1383 Smith K, Bryant RA. 2000. The generality of cognitive bias in acute stress disorder. *Behaviour*
1384 *Research and Therapy* 38: 709-715 DOI: 10.1016/S0005-7967(99)00096-0.
- 1385 Smyth R. 2012. Bum Fodder: An Absorbing History of Toilet Paper. *London: Souvenir Press*
1386 *Limited*.
- 1387 Soria V, Uribe J, Salvat-Pujol N, Palao D, Menchón JM, Labad J. 2018.
1388 Psychoneuroimmunology of mental disorders. *Revista de Psiquiatria y Salud Mental* 11:115-
1389 124. DOI: 10.1016/j.rpsm.2017.07.006.
- 1390 Statista Consumer Market Outlook. 2020. Tissue and Hygiene Paper Report 2020 – Toilet Paper.
1391 Available at <https://www.statista.com/study/48850/tissue-and-hygiene-paper-report-toilet-paper/>
- 1392 Steketee G, Frost R. 2003. Compulsive hoarding: Current status of the research. *Clinical*
1393 *Psychology Review* 23: 905-927. DOI: 10.1016/j.cpr.2003.08.002.
- 1394 Storch EA, Nadeau JM, Johnco C, Timpano K, McBride N, Jane Mutch P, Lewin AB, Murphy
1395 TK. 2016. Hoarding in Youth with Autism Spectrum Disorders and Anxiety: Incidence, Clinical
1396 Correlates, and Behavioral Treatment Response. *Journal of Autism and Developmental*
1397 *Disorders* 46: 1602-1612. DOI: 10.1007/s10803-015-2687-z.
- 1398 The Lancet. 1869. Notes, Short Comments, and Answers to Correspondents: Medicated paper.
1399 *Lancet* 94:531.
- 1400 Thielmann I, Hilbig BE. 2015. The Traits One Can Trust: Dissecting Reciprocity and Kindness
1401 as Determinants of Trustworthy Behavior. *Personality and Social Psychology Bulletin* 41: 1523-
1402 1536. DOI: 10.1177/0146167215600530.
- 1403 Tolin DF, Meunier SA, Frost RO, Steketee G. 2010. Course of compulsive hoarding and its
1404 relationship to life events. *Depression and Anxiety* 27: 829-838 . DOI: 10.1002/da.20684.
- 1405 Tolin DF, Meunier SA, Frost RO, Steketee G. 2011. Hoarding among patients seeking treatment
1406 for anxiety disorders. *Journal of Anxiety Disorders* 25: 43-48. DOI:
1407 10.1016/j.janxdis.2010.08.001.
- 1408 Törnberg P. 2018. Echo chambers and viral misinformation: Modeling fake news as complex
1409 contagion. *PLoS ONE* 13: e0203958. DOI: 10.1371/journal.pone.0203958.

- 1410 Van Bockstaele B, Notebaert L, Saleminck E, Clarke PJF, MacLeod C, Wiers RW, Bögels SM.
1411 2019. Effects of interpretation bias modification on unregulated and regulated emotional
1412 reactivity. *Journal of Behavior Therapy and Experimental Psychiatry* 64: 123-132. DOI:
1413 10.1016/j.jbtep.2019.03.009.
- 1414 van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, Tamin
1415 A, Harcourt JL, Thornburg NJ, Gerber SI, Lloyd-Smith JO, de Wit E, Munster VJ. 2020. Aerosol
1416 and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1. *The New England*
1417 *Journal of Medicine* 382:1564-1567. DOI: 10.1056/NEJMc2004973.
- 1418 Vogel B, Trotzke P, Steins-Loeber S, Schäfer G, Stenger J, De Zwaan M, Brand M, Müller A.
1419 2019. An experimental examination of cognitive processes and response inhibition in patients
1420 seeking treatment for buying-shopping disorder. *PLoS ONE* 14:e0212415 . DOI:
1421 10.1371/journal.pone.0212415.
- 1422 Vosoughi S, Roy D, Aral S. 2018. The spread of true and false news online. *Science* 359:1146-
1423 1151. DOI: 10.1126/science.aap9559.
- 1424 Wang W, Xu Y, Gao R, Lu R, Han K, Wu G, Tan W. 2020c. Detection of SARS-CoV-2 in
1425 Different Types of Clinical Specimens. *JAMA - Journal of the American Medical Association*
1426 323: 1843-1844. DOI: 10.1001/jama.2020.3786.
- 1427 Wang X, Fang J, Zhu Y, Chen L, Ding F, Zhou R, Ge L, Wang F, Chen Q, Zhang Y, Zhao Q.
1428 2020a. Clinical characteristics of non-critically ill patients with novel coronavirus infection
1429 (COVID-19) in a Fangcang Hospital. *Clinical Microbiology and Infection* 26:1063-1068. DOI:
1430 10.1016/j.cmi.2020.03.032.
- 1431 Wang X, Liu W, Zhao J, Lu Y, Wang X, Yu C, Hu S, Shen N, Liu W, Sun Z, Li W. 2020b.
1432 Clinical characteristics of 80 hospitalized frontline medical workers infected with COVID-19 in
1433 Wuhan, China. *Journal of Hospital Infection* 105: 399-403. DOI: 10.1016/j.jhin.2020.04.019.
- 1434 Wang Z, Wang Y, Zhao Q, Jiang K. 2016. Is the DSM-5 hoarding disorder diagnosis valid in
1435 China? *Shanghai Archives of Psychiatry* 28: 103-105. DOI: 10.11919/j.issn.1002-0829.215054.
- 1436 Wei XS, Wang X, Niu YR, Ye LL, Peng WB, Wang ZH, Yang WB, Yang BH, Zhang JC, Ma
1437 WL, Wang XR, Zhou Q. 2020. Diarrhea is associated with prolonged symptoms and viral
1438 carriage in COVID-19. *Clinical Gastroenterology and Hepatology* 18: 1753-1759.e2. DOI:
1439 10.1016/j.cgh.2020.04.030.
- 1440 Wells G, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. 2012. The Newcastle-
1441 Ottawa Scale (NOS) for assessing the quality if nonrandomized studies in meta-analyses.
1442 Available at http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp. DOI:
1443 10.2307/632432.
- 1444 Wheaton MG, Abramowitz JS, Jacoby RJ, Zwerling J, Rodriguez CI. 2016. An investigation of
1445 the role of intolerance of uncertainty in hoarding symptoms. *Journal of Affective Disorders* 193:
1446 208-214. DOI: 10.1016/j.jad.2015.12.047.
- 1447 White J. 2020. Lionel Messi takes on '10-touch toilet paper challenge' during coronavirus
1448 lockdown. Available at [https://www.scmp.com/sport/football/article/3076057/lionel-messi-takes-](https://www.scmp.com/sport/football/article/3076057/lionel-messi-takes-10-touch-toilet-paper-challenge-during)
1449 [10-touch-toilet-paper-challenge-during](https://www.scmp.com/sport/football/article/3076057/lionel-messi-takes-10-touch-toilet-paper-challenge-during)

- 1450 WHO Coronavirus Disease (COVID-19) Dashboard. Available at <https://covid19.who.int/>
- 1451 Wong G, Greenhalgh T, Westhorp G, Buckingham J, Pawson R. 2013. RAMESES publication
1452 standards: Realist syntheses. *BMC Medicine* 11:21. DOI: 10.1186/1741-7015-11-21.
- 1453 Wong SH, Lui RNS, Sung JJY. 2020. Covid-19 and the digestive system. *Journal of*
1454 *Gastroenterology and Hepatology*. 35: 744-748. DOI: 10.1111/jgh.15047.
- 1455 Wood KA. 2020. A Psychoanalysis of Toilet Paper and Freudian Wisdom in the Corona-
1456 pocalypse. Available at [https://medium.com/@kristiewood/a-psychoanalysis-of-toilet-paper-](https://medium.com/@kristiewood/a-psychoanalysis-of-toilet-paper-freudian-wisdom-in-the-corona-pocalypse-e664f2c2e3c6)
1457 [freudian-wisdom-in-the-corona-pocalypse-e664f2c2e3c6](https://medium.com/@kristiewood/a-psychoanalysis-of-toilet-paper-freudian-wisdom-in-the-corona-pocalypse-e664f2c2e3c6)
- 1458 Worden B, Levy HC, Das A, Katz BW, Stevens M, Tolin DF. 2019. Perceived emotion
1459 regulation and emotional distress tolerance in patients with hoarding disorder. *Journal of*
1460 *Obsessive Compulsive and Related Disorders* 22: 100441. DOI: 10.1016/j.jocrd.2019.100441.
- 1461 World Bank Group. 2000a. People practicing open defecation, rural (% of rural population).
1462 Available at <https://data.worldbank.org/indicator/SH.STA.ODFC.RU.ZS>
- 1463 World Bank Group. 2000b. People practicing open defecation, urban (% of urban population).
1464 Available at <https://data.worldbank.org/indicator/SH.STA.ODFC.UR.ZS>
- 1465 Worobey M, Cox J, Gill D. 2019. The origins of the great pandemic. *Evolution, Medicine and*
1466 *Public Health* 2019: 18-25. DOI: 10.1093/emph/eoz001.
- 1467 Xiao F, Tang M, Zheng X, Liu Y, Li X, Shan H. 2020. Evidence for Gastrointestinal Infection of
1468 SARS-CoV-2. *Gastroenterology* 158: 1831-1833.e3. DOI: 10.1053/j.gastro.2020.02.055.
- 1469 Xu XW, Wu XX, Jiang XG, Xu KJ, Ying LJ, Ma CL, Li SB, Wang HY, Zhang S, Gao HN,
1470 Sheng JF, Cai HL, Qiu YQ, Li LJ. 2020b. Clinical findings in a group of patients infected with
1471 the 2019 novel coronavirus (SARS-Cov-2) outside of Wuhan, China: Retrospective case series.
1472 *BMJ* 368: m792. DOI: 10.1136/bmj.m606.
- 1473 Xu Y, Li X, Zhu B, Liang H, Fang C, Gong Y, Guo Q, Sun X, Zhao D, Shen J, Zhang H, Liu H,
1474 Xia H, Tang J, Zhang K, Gong S. 2020a. Characteristics of pediatric SARS-CoV-2 infection and
1475 potential evidence for persistent fecal viral shedding. *Nature Medicine* 26: 502-505. DOI:
1476 10.1038/s41591-020-0817-4.
- 1477 Yeo C, Kaushal S, Yeo D. 2020. Enteric involvement of coronaviruses: is faecal–oral
1478 transmission of SARS-CoV-2 possible? *The Lancet Gastroenterology and Hepatology* 5: 335-
1479 337. DOI: 10.1016/S2468-1253(20)30048-0.
- 1480 Yu M, Westenberg PM, Li W, Wang J, Miers AC. 2019. Cultural evidence for interpretation bias
1481 as a feature of social anxiety in Chinese adolescents. *Anxiety, Stress and Coping* 32: 376-386
1482 DOI: 10.1080/10615806.2019.1598556.
- 1483 Yu R. 2016. Stress potentiates decision biases: A stress induced deliberation-to-intuition (SIDI)
1484 model. *Neurobiology of Stress* 3: 83-95. DOI: 10.1016/j.ynstr.2015.12.006.
- 1485 Zhang H, Li HB, Lyu JR, Lei XM, Li W, Wu G, Lyu J, Dai ZM. 2020a. Specific ACE2
1486 expression in small intestinal enterocytes may cause gastrointestinal symptoms and injury after
1487 2019-nCoV infection. *International Journal of Infectious Diseases* 96: 19-24. DOI:
1488 10.1016/j.ijid.2020.04.027.

1489 Zhang J, Liu P, Wang M, Wang J, Chen J, Yuan W, Li M, Xie Z, Dong W, Li H, Zhao Y, Wan
1490 L, Chu T, Wang L, Zhang H, Tao T, Ma J. 2020b. The clinical data from 19 critically ill patients
1491 with coronavirus disease 2019: a single-centered, retrospective, observational study. *Journal of*
1492 *Public Health*. DOI: 10.1007/s10389-020-01291-2.

1493 Zhao XY, Xu XX, Yin H Sen, Hu QM, Xiong T, Tang YY, Yang AY, Yu BP, Huang ZP. 2020.
1494 Clinical characteristics of patients with 2019 coronavirus disease in a non-Wuhan area of Hubei
1495 Province, China: A retrospective study. *BMC Infectious Diseases*. DOI: 10.1186/s12879-020-
1496 05010-w.

1497 Zhou N. 2020. Off the chart: Australians were world leaders in panic buying, beating UK and
1498 Italy. *The Guardian*.

1499 Zhu J, Ji P, Pang J, Zhong Z, Li H, He C, Zhang J, Zhao C. 2020. Clinical characteristics of
1500 3,062 COVID-19 patients: a meta-analysis. *Journal of Medical Virology*. DOI:
1501 10.1002/jmv.25884.
1502

Table 1 (on next page)

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 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	Toilet paper hoarding

Table 2 (on next page)

Main characteristics of case reports included in the Systematic Review (n=6)

1 **Table 2. Main characteristics of case reports 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	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	58	Man	NR	Schizophrenia	NR	No hoarding behaviour	Suicidal asphyxia by toilet paper	12/13	5c, 5d
3	Saint-Martin et al., 2007	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	91	Woman	NR	Alzheimer's disease	NA	No hoarding behaviour	Homicidal asphyxia by toilet paper	12/13	5c, 5d
5	Fisher et al., 2014	30	Man	NR	Pica	NR	No hoarding behaviour	Gastritis by toilet paper ingestion (Pica)	10/13	5d, 7, 10c
6	Chisholm and Martin, 1981	37	Woman	NR	Pica	Zinc and ferrous sulfate	No hoarding behaviour	Pica by toilet paper ingestion	12/13	5c

2

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.

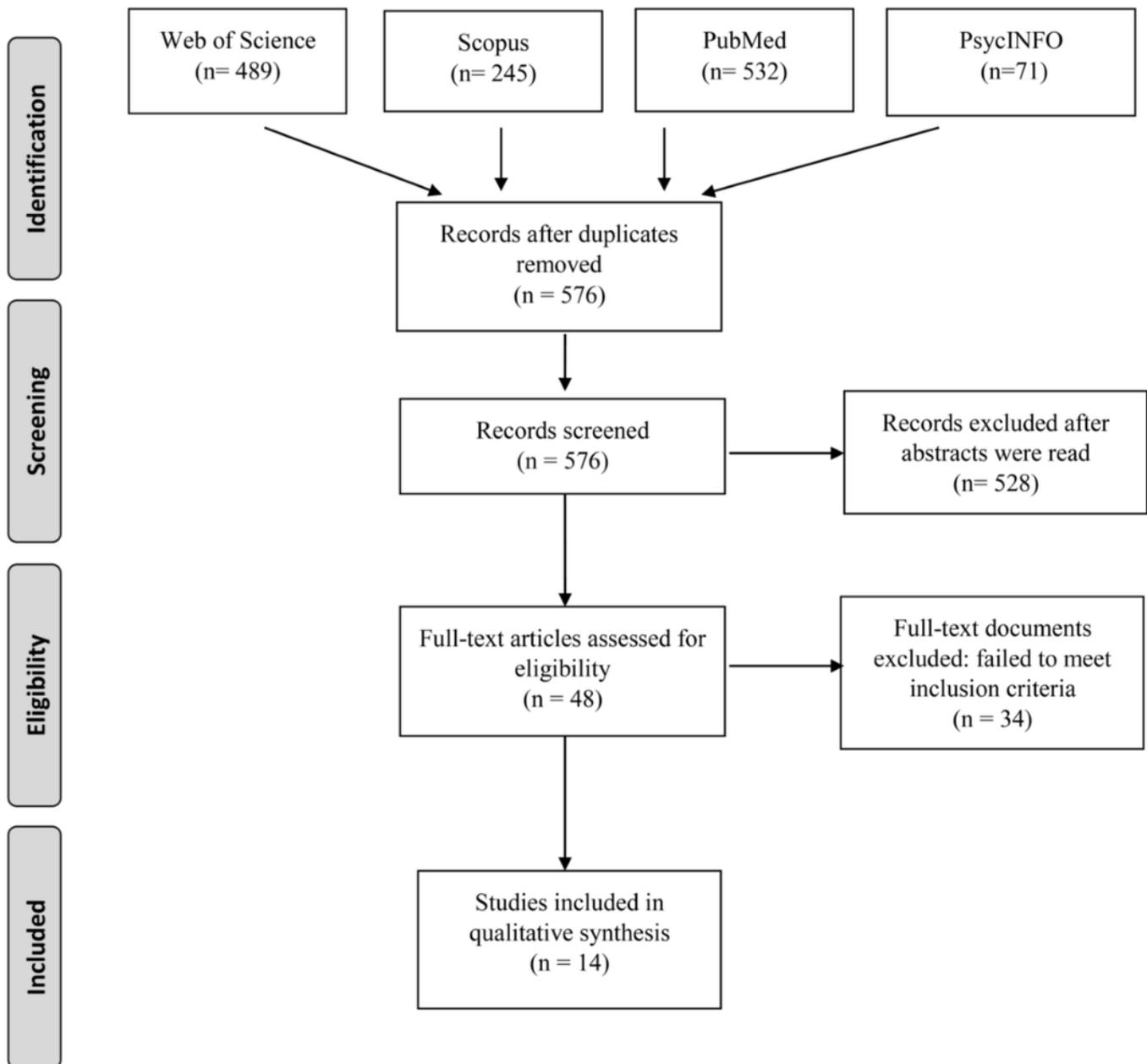


Figure 2

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

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

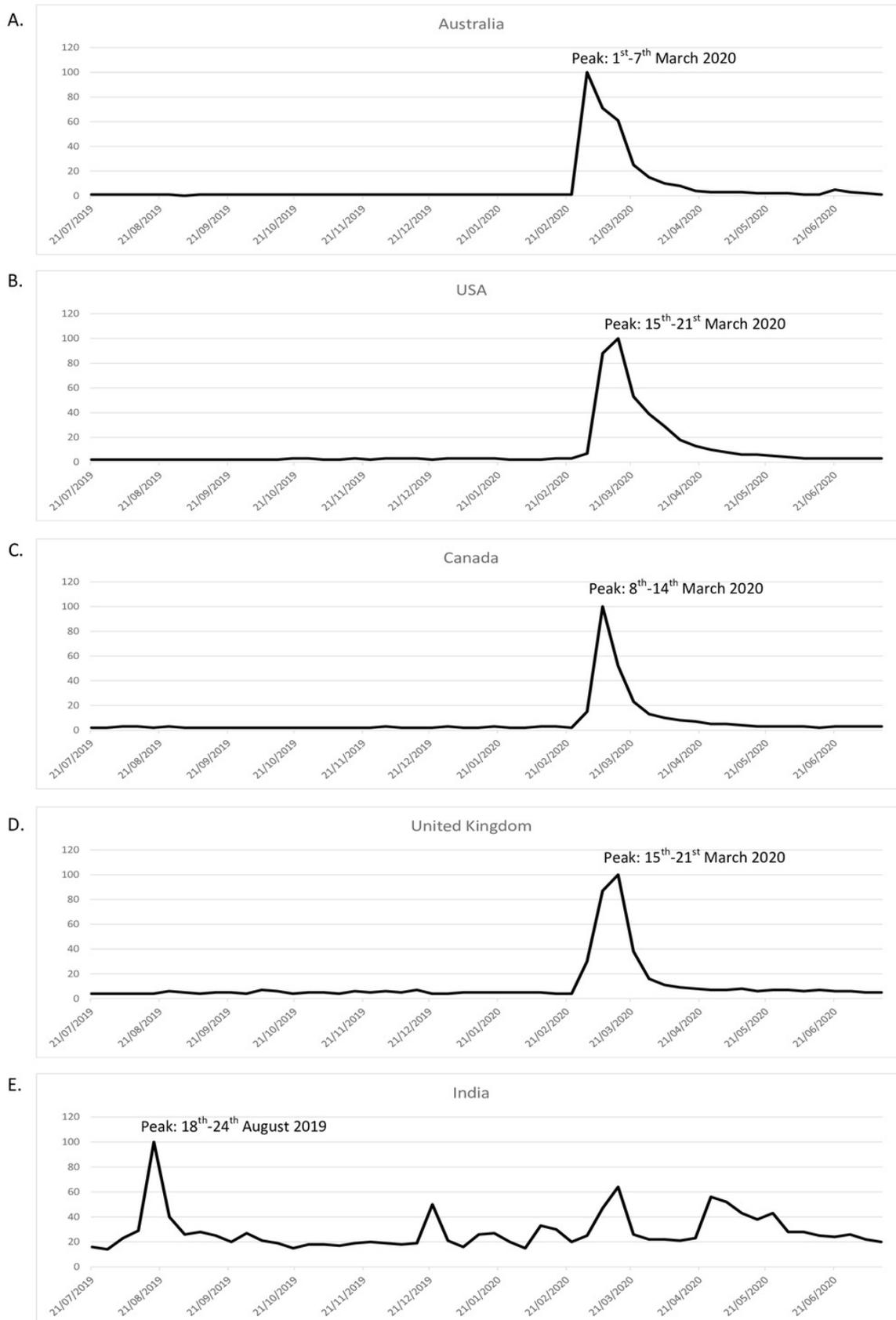


Figure 3

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; Shizoffective D.= Schizoffective 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.

