

# 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.

**Registration:** PROSPERO CRD42020182308

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4

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## 24 **Abstract**

25 **Objective:** To explore whether the coronavirus disease 2019 (COVID-19) pandemic is associated with  
26 toilet paper hoarding and to assess which risk factors are associated with the risk of toilet paper hoarding.

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47 cognitive biases and a bandwagon effect were potential contributors to toilet paper hoarding in the general  
48 population. The stressful situation (COVID-19 pandemic) and some personality traits (conscientiousness)  
49 were found to be associated with toilet paper hoarding. Cultural differences were also identified, with  
50 relatively substantial effects of toilet paper hoarding in several Asian regions (Australia, Japan, Taiwan  
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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 31<sup>st</sup> 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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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

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**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 <sup>*,#</sup>
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,

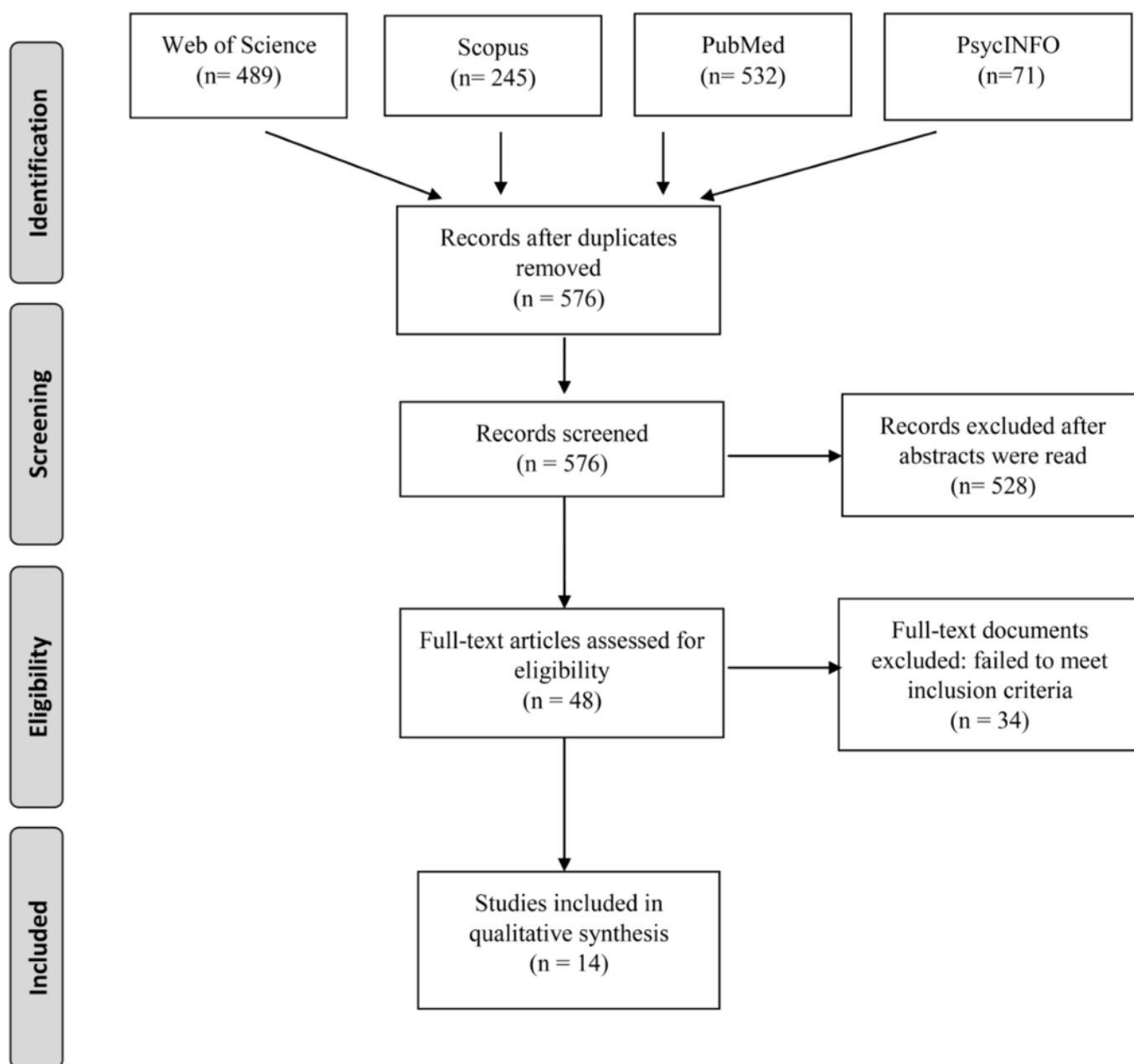
4 13.

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.

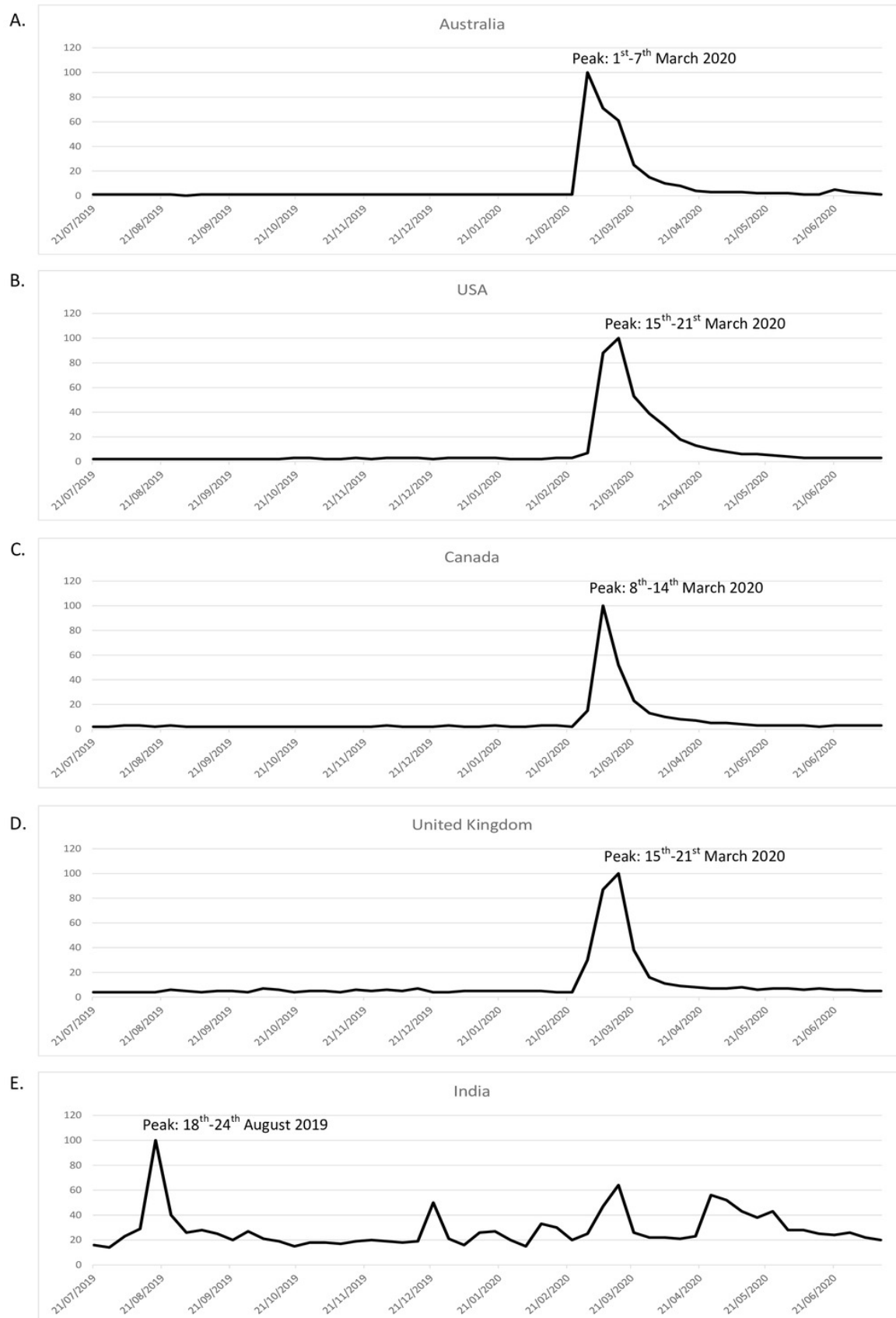


## Figure 2

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 - 5<sup>th</sup> edition; GAD= Generalised anxiety disorder; OCPD= Obsessive-compulsive personality disorder.

