

1 **A realistic touch-transfer method reveals low risk of transmission for**
2 **SARS-CoV-2 by contaminated coins and bank notes**

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42

43 **Abstract**

44 The current severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic
45 has created a significant threat to global health. While respiratory aerosols or droplets
46 are considered as the main route of human-to-human transmission, secretions expelled
47 by infected individuals can also contaminate surfaces and objects, potentially creating
48 the risk of fomite-based transmission. Consequently, frequently touched objects such as
49 paper currency and coins have been suspected as a potential transmission vehicle. To
50 assess the risk of SARS-CoV-2 transmission by banknotes and coins, we examined the
51 stability of SARS-CoV-2 and bovine coronavirus (BCoV), as surrogate with lower
52 biosafety restrictions, on these different means of payment and developed a touch
53 transfer method to examine transfer efficiency from contaminated surfaces to skin.
54 Although we observed prolonged virus stability, our results, including a novel touch
55 transfer method, indicate that the transmission of SARS-CoV-2 via contaminated coins
56 and banknotes is unlikely and requires high viral loads and a timely order of specific
57 events.

58

59 **Key words:** SARS-CoV-2, stability, coins, banknotes, human skin

60

61 **1. Introduction**

62 The current severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) pandemic
63 has created a significant threat to global health. Since effective treatments and access to
64 vaccines is still limited for the broad population in most countries, diligent attention on
65 transmission-based precautions is essential to limit viral spread. In particular considering
66 the emergence of novel SARS-CoV-2 variants with possibly greater risk of transmission
67 [1,2]. According to current evidence, SARS-CoV-2 is mainly transmitted through
68 respiratory droplets and aerosols exhaled from infected individuals [3]. Respiratory
69 secretions or droplets expelled by infected individuals can potentially contaminate
70 surfaces and objects (fomites) and have been shown to persist on inanimate surfaces for
71 days under controlled laboratory conditions [4,5]. Therefore, a clinically significant risk
72 of SARS-CoV-2 transmission by fomites has been assumed [6–8]. The COVID-19
73 pandemic intensified the decline in the transactional use of cash, partly due to reduced
74 consumer spending, but also due to concerns about the risk of banknotes transmitting the
75 virus. This was observed for either sides, the retailers' as well as the customers [9].
76 Indeed, frequently touched objects such as banknotes and coins have been suspected to
77 serve as transmission vehicle of various pathogenic bacteria, parasites, fungi and viruses
78 including SARS-CoV-2 [10,11]. However, the conditions presented in various
79 experimental studies frequently do not resemble real-life scenarios (e.g. large virus
80 inoculums, small surface area) and thereby potentially exaggerating the risk of
81 transmission of SARS-CoV-2 by fomites [12,13]. Although different viruses are readily
82 exchanged between skin and surfaces, the fraction of virus transferred is dependent on
83 multiple factors including virus species and surface material [14]. The efficiency of
84 pathogen transfer from the fomite to hands is an important parameter to model its

85 potential for transmission and to implement effective hygiene measures, while avoiding
86 unnecessary measures [15]. However, the transfer of SARS-CoV-2 from surfaces to skin
87 has not been analyzed systematically. Here, we examined the stability of SARS-CoV-2
88 and bovine coronavirus (BCoV) as surrogate on different means of payment. We further
89 implemented a new protocol to study the touch transfer efficiency between fomites and
90 skin. Importantly, we only observed a transfer between fomites and skin using a large
91 initial virus titer sample (10^6 infectious virus particles) on the tested surfaces, while
92 lower initial virus titer stocks (10^4 infectious virus particles) were not effectively
93 transferred.

94 Overall, our results point to a low risk of SARS-CoV-2 transmission by coins and
95 banknotes and the tendency to prefer contactless payment over cash during the pandemic
96 seems unnecessary.

97

98 **Materials and methods**

99

100 *Preparation of test virus suspension*

101 For preparation of SARS-CoV-2 test virus suspension, Vero E6 cells were seeded in a
102 75 cm² flasks at 2×10⁶ cells in Dulbecco's Modified Eagle's Medium (DMEM,
103 supplemented with 10 % (v/v) fetal calf serum (FCS), 1 % non-essential amino acids,
104 100 IU/mL penicillin, 100 µg/mL streptomycin and 2 mM L-Glutamine). The monolayer
105 was inoculated with the hCoV-19/Germany/BY-Bochum-1/2020 (GISAID accession
106 ID: EPI_ISL_1118929). After 3 days and upon visible cytopathic effect the supernatant
107 was harvested by centrifugation at 1500 rpm for 5 min at room temperature, aliquoted
108 and stored at -80 °C until further usage.

109 For preparation of BCoV virus suspension, U373 cells were cultivated in a 75 cm² flask
110 with in Minimum Essential Medium Eagle (EMEM) supplemented with L-glutamine,
111 non-essential amino acids and sodium pyruvate and 10 % FCS. Before virus infection,
112 cells were washed two times with phosphate buffered saline (PBS), incubated for 3 h
113 with serum-free EMEM and were washed once with EMEM supplemented with trypsin.

114 For virus production, BCoV strain L9 (NCBI: txid11130) was added to the prepared
115 monolayer. After an incubation period of 24 to 48 hours cells were lysed by a rapid
116 freeze/thaw cycle followed by a low speed centrifugation in order to sediment cell debris.

117 After aliquoting of the supernatant, test virus suspension was stored at -80 °C. Nine
118 volumes of test virus suspension were mixed with one volume of interfering substance
119 solution [0.3 g/L bovine serum albumin (BSA) in PBS according to EN 16777, section
120 5.2.2.8]. The tests were performed with two different virus concentrations, i.e. a titer of

121 approximately 10^4 50% tissue culture infectious dose per milliliter (TCID₅₀/mL) and a
122 titer of 10^6 TCID₅₀/mL.

123

124 *Preparation of specimens*

125 Prior to use regular 5-, 10-cent and 1-euro coins were dipped in a bath containing 70 %
126 (v/v) ethanol for 5 min. The 10- and 50-euro banknotes (provided by the European
127 Central Bank) and PVC plates [with PUR (polyurethane) surface coating 20 x 50 cm
128 (VAH e.V.), precleaned with 70.0 % propan-1-ol or ethanol] were cut into pieces of 2 x
129 2 cm. Banknotes were UV irradiated before the tests. Stainless steel discs (2 cm diameter
130 discs) with Grade 2 B finish on both sides (article no. 4174-3000, GK Formblech GmbH,
131 Berlin, Germany) served as reference control. Prior to use the discs were decontaminated
132 with 5 % (v/v) Decon 90 for 60 minutes and 70 % (v/v) propan-2-ol for 15 min.
133 Subsequently, the discs were rinsed with distilled water sterilized by autoclaving (steam
134 sterilization).

135

136 *Inactivation assays and controls*

137 For stability testing, specimens were placed aseptically in a Petri dish and inoculated
138 with 50 µL of the virus inoculum [5×10 µL drops, i.e. four in every corner and one in
139 the middle of the square (Fig. 3)]. After visible drying of the inoculum, the petri dishes
140 were closed and the specimens were incubated until the end of the appropriate exposure
141 time (up to 7 days). After the respective time, the specimens were transferred to 2 mL
142 cell culture medium (without FCS) in a 25 mL container and vortexed for 60 seconds to
143 resuspend the virus. Directly after elution, series of ten-fold dilutions of the eluate in ice-
144 cold maintenance medium were prepared and inoculated on cell culture.

145 Fifteen and 30 minutes, 1, 2, 7, and 24 hours and 2, 3, 5 and 7 days were chosen as
146 application times. Eluates were retained after appropriate drying times and residual
147 infectivity was determined.

148 The initial virus titer (VIC) was determined by addition of 50 μ L of the virus inoculum
149 directly to 2 mL cell culture medium without any desiccation.

150

151 *Touch transfer test*

152 For the touch transfer test with BCoV, three test persons simulated the transfer by
153 pressing a finger shortly on the dried inoculum on the respective carriers followed by
154 rubbing once with pressure over the carrier. Three other test persons simulated the
155 transfer by a fingerprint of 5 seconds on the dried inoculum on the different carriers.
156 Each test person performed the transfer test separately with the two different virus
157 concentrations (10^4 TCID₅₀/mL and 10^6 TCID₅₀/mL) with 8 fingers each. For each test
158 person and virus concentration, two fingers were used for virus transfer without drying
159 of the inoculum. The transfer procedure was the same as with the dried inoculum.

160 The amount of transferred virus to the fingers was obtained by dipping and rubbing each
161 finger in turn for one minute on the base of a Petri dish containing 2 mL cell culture
162 medium without FCS as sample fluid. For each finger a separate dish was used. The
163 eluates were transferred in a 25 mL container. Directly after elution, series of ten-fold
164 dilutions of the eluate in ice-cold maintenance medium were prepared and inoculated on
165 cell culture. The initial virus titer (VIC) was determined by addition of 50 μ L of the virus
166 inoculum directly to 2 mL cell culture medium without any drying. Furthermore, a cell
167 control (only addition of medium) was incorporated.

168 For the touch transfer test of SARS-CoV-2, one person performed all assays due to BSL3
169 restrictions. To mimic the texture and nature of human fingertips, we used VITRO-SKIN
170 (IMS Florida Skincare Testing, FL, USA), an artificial skin substitute, placed in a plastic
171 frame was used (Fig. 3). After printing or rubbing as described above, the complete
172 artificial skin was released from the frame and transferred into a 25 mL container with
173 serum-free cell culture medium and vortexed for 60 s.

174

175 *Determination of infectivity*

176 Infectivity was determined by means of end point dilution titration using the microtiter
177 process. For this, samples were immediately diluted at the end of the exposure time with
178 ice-cold EMEM containing trypsin and 100 μ L of each dilution were placed in 6 or 8
179 wells of a sterile polystyrene flat-bottomed plate with a preformed U373 (BCoV) or Vero
180 6 (SARS-CoV-2) monolayer. Before addition of virus, cells were washed twice with
181 EMEM (U373) or DMEM (Vero 6) and incubated for 3 h with 100 μ L EMEM (U373)
182 or DMEM (Vero 6) with trypsin. After 3 d or 6 d incubation at 37 °C in a CO₂-
183 atmosphere (5.0 % CO₂-content), cultures were observed for cytopathic effects.
184 TCID₅₀/mL was calculated according to the method of Spearman and Kärber [16].

185

186 *Fitting of virus titer decay*

187 To model the decay in virus titer, we implemented a Weibull distribution fit in GraphPad
188 Prism version 9.0.2 for Windows (GraphPad Software, San Diego, California USA,
189 www.graphpad.com)

190

191

192 *Calculation of the reduction factor*

193 The loss in virus titer by desiccation was calculated by subtracting the titer on the
194 different carriers after desiccation from the titer of the initial virus control. The amount
195 of transferred virus (TCID₅₀/mL) from the different carriers to the fingers was also
196 calculated with the method of Spearman and Kärber [16].

197

198

199 **Results**

200

201 **Stability of BCoV on euro banknotes**

202 To examine the stability of coronaviruses on banknotes we first used bovine coronavirus
203 (BCoV), which can be cultivated under lower biosafety levels and has been used as a
204 surrogate virus for inactivation studies replacing the highly pathogenic MERS-CoV and
205 SARS-CoV [17]. All euro banknotes are made of pure cotton fiber. To protect the surface
206 of banknotes with smaller denomination and prolong circulation life, 5 € and 10 €
207 banknotes are coated with a varnish applied after printing [18]. To account for the effect
208 of this varnish on surface stability of BCoV over time, we assessed residual infectivity
209 from pieces of 10 € and 50 € banknotes for 7 h, 24 h and subsequently every 24 – 48 h
210 up to 7 days (Fig. 1A). The initial virus concentration of 4.3×10^6 TCID₅₀/mL declined
211 to 1.84×10^4 TCID₅₀/mL on 10 € banknotes and 9.25×10^4 TCID₅₀/mL on 50 €
212 banknotes after 7 h desiccation. To quantitatively compare this early loss of titer on the
213 different surfaces, we employed a fitted Weibull distribution model to estimate initial
214 decay rates and the modelled time to lower limit of quantification (Fig. 1B, Table 1). For
215 both banknotes we observed shorter initial decay (2.75 h on 50€ and 6.45 h on 10€) as
216 compared to the steel disc (49.62 h) (Fig. 1B, Table 1). Following the strong initial decay,
217 we were able to detect low amounts of infectious virus after 120 h (50€) and 168 h (10€)
218 respectively (Fig. 1A), which is very much in line with the observed times in the model
219 of 175.62 h for 50€. and 216.31 h for 10€ notes (Fig. 1B and Table 1). In contrast, on
220 steel discs a more continuous decay was observed and infectious virus could be
221 recovered up to 120 h (Fig. 1A), and 229.73 h for the fitted model, respectively (Fig. 1B,
222 Table 1).

223 **Stability of SARS-CoV-2 on euro banknotes and coins**

224 We next examined the surface stability of infectious SARS-CoV-2 on 10 € banknotes,
225 different coins (1 €, 10 cents, 5 cent) and stainless-steel discs for up to 7 days using an
226 initial virus concentration of $1.36 - 2.0 \times 10^6$ TCID₅₀/mL (Fig. 2). On 10 € banknotes
227 and 1 € coins, the initial virus concentration declined to 2.32×10^4 TCID₅₀/mL and 1.79
228 $\times 10^4$ TCID₅₀/mL, respectively, after 1.25 h, corresponding to an estimated initial decay
229 time of 6.07 h and 2.21 h (Fig. 2B, Table 1). No infectious virus could be recovered after
230 72 h and 48 h (Fig. 2A) matching 85.67 h and 28.43 h survival time (Fig. 2B, Table 1).
231 In contrast, on 10 cent and 5 cent coins the initial virus concentration declined to 5.96
232 $\times 10^4$ TCID₅₀/mL and 3.86×10^1 TCID₅₀/mL, respectively, within 30 min. Initial decay
233 rates were calculated as 49.8 min (10 cent) and 12 min (5 cent) (Fig. 2B, Table 1).
234 Importantly, from 10 cent coins no infectious virus could be recovered after 6 h, while
235 for 5 cent coins infectivity was completely lost after 1 h (Fig. 2A), as reflected by 2.28
236 h and 33 min survival time for SARS-CoV-2 on 10 cent and 5 cent coins (Fig. 2B, Table
237 1). In contrast, on stainless-steel discs, which served as reference material, initial decay
238 and time to reach background levels were comparable to BCoV with 20.59 h and 158.83
239 h, respectively (Fig. 2B, Table 1). Virus titers declined more evenly until no infectious
240 virus could be recovered after 120 h (Fig. 2A).

241

242 **Development of a touch transfer assay to study virus transfer between cash and** 243 **finger pads**

244 Experiments performed under controlled laboratory conditions demonstrated the
245 persistence of SARS-CoV-2 on inanimate surfaces for days and consequently implied
246 the risk of viral transmission via contaminated objects [5,19]. However, to develop more

247 refined models to assess the risk of fomites-based transmission of SARS-CoV-2,
248 quantitative measurements of the transfer efficiency of infectious virus between skin and
249 surfaces are required. To address these limitations, we developed a touch transfer assay
250 to study the transfer of infectious BCoV and SARS-CoV-2 between finger pads and
251 different fomites (Fig. 3). Briefly, virus suspensions were placed on different surfaces
252 (pieces of 10 € banknotes, 10 cent coins, pieces of PVC to mimic the surface of credit
253 cards and stainless-steel discs as reference material). Afterwards, the wet inoculum or
254 the dried suspension was touched by “printing” or “rubbing” using finger pads (BCoV)
255 or an artificial skin fabric (SARS-CoV-2) (Fig. 3). Subsequently, infectious viruses were
256 recovered by dipping and rubbing each fingertip in turn for one minute on the base of a
257 Petri dish containing 2 mL of EMEM cell culture medium (BCoV) or, in case of the
258 artificial skin, by directly placing it into a container with cold DMEM (SARS-CoV-2).
259 The resulting suspension was serially diluted to determine TCID₅₀/mL values of the
260 remaining infectious virus.

261

262 **Transferability of BCoV from banknotes, coins and PVC to fingertips**

263 Using this newly developed touch transfer assay, we examined the transmission of BCoV
264 from different surfaces, i.e. pieces of 10 € banknotes, 10 cent coins, pieces of PVC and
265 stainless-steel discs as reference material, to fingertips. Surfaces were inoculated with
266 either a high ($\sim 1 \times 10^6$ TCID₅₀/mL) or low ($\sim 1 \times 10^4$ TCID₅₀/mL) viral titer to represent
267 different degrees of surface contamination. Virus transfer was assessed directly
268 following application to fomites (wet) or after ~ 1 h until completely dried (dry) by either
269 pressing (print) or rubbing (rub) the fingertip onto the surface. Initial virus (input) was
270 determined by applying the fomites directly to the medium container. For a high initial

271 titer and direct surface contact, we observed a maximum of a 0.6 log₁₀ reduction for the
272 10-cent coin, while lower reduction factors were observed for the other surfaces (Fig.
273 4A). In case of drying the initial inoculum followed by a fingerprint, we observed a 2.1
274 log₁₀ reduction on a 10 € banknote, while lower reduction factors were observed for the
275 other surfaces. For a low initial titer and direct surface contact, we observed the highest
276 reduction on the stainless-steel carrier (1.2 log₁₀ reduction). In case of drying the initial
277 inoculum followed by a fingerprint, we observed a 0.8 log₁₀ reduction on a 10-cent coin.
278 Importantly, no infectious virus could be recovered from the 10 € banknote under these
279 conditions.

280

281 **Transferability of SARS-CoV-2 from banknotes, coins and pvc to skin**

282 Next, we examined the transmission of infectious SARS-CoV-2 from surfaces to
283 fingertips. Surfaces were inoculated with either a high ($\sim 1 \times 10^6$ TCID₅₀/mL) or low (\sim
284 1×10^4 TCID₅₀/mL) titer to represent different degrees of surface contamination. As
285 described before, virus transfer was assessed directly following inoculation (wet) or after
286 drying either by printing (print) or rubbing (rub). For a high initial titer and direct surface
287 contact, we observed a maximum of a 1 log₁₀ reduction for the 10-cent coin, while lower
288 reduction factors were observed for the other surfaces (Fig. 5A). Drying of the initial
289 inoculum led to ~ 1 log loss in virus titer. In the dried state, less virus was transferred
290 and could be recovered, e.g. by fingerprint we observed a 3.0 log₁₀ reduction on the 10-
291 cent coin, while lower reduction factors were observed for the other surfaces. For a low
292 initial titer and direct surface contact, we observed the highest reduction on the 10 €
293 banknote (0.7 log₁₀ reduction). In case of drying the initial inoculum followed by a
294 fingerprint we observed a reduction of the initial inoculum close/under the limit of

295 detection and only from the PVC very low (2.19×10^1 TCID₅₀/mL) amounts of infectious
296 virus could be recovered (Fig. 5B).
297

298 **4. Discussion**

299 Human-to-human transmission of SARS-CoV-2 occurs primarily by respiratory aerosols
300 or droplets and subsequent contact to nasal, oral, or ocular mucosal membranes.
301 Evidence-to-date further suggests that fomite transmission is possible for SARS-CoV-2
302 [5,19], however, the importance of this route in healthcare and public settings remains
303 controversial [12,13,20]. Fomite-based transmission contributes to the spread of other
304 common respiratory pathogens [21,22]. Consequently, paper currency and coins have
305 been suspected as a potential transmission vehicle for various pathogens, including
306 SARS-CoV-2 [10,11,23]. Although infectious viruses have not been directly detected on
307 banknotes or coins, the potential for their transmission has been highlighted by the
308 observation that human influenza viruses were able to persist and remain infectious for
309 several days when they were deposited on banknotes [24]. Furthermore, many other
310 viruses, (i.e. Adenoviruses, Rotaviruses) are stable in the environment and exhibit high
311 infectivity and, thus, could possibly be transferred by banknotes and coins [25]. In
312 agreement with previous reports we found that high titers of SARS-CoV-2 and its
313 surrogate BCoV, after an initial loss of infectivity, remained infectious for days under
314 laboratory conditions on banknotes and coins (Table 1, Fig. 1 and 2) [19,26]. The initial
315 loss of infectivity was higher on coins and banknotes, irrespective of protective varnish,
316 when compared to stainless steel, indicating faster desiccation due to liquid absorption
317 (banknotes) or antiviral surface properties (e.g. copper in coins). Both BCoV and SARS-
318 CoV-2 displayed highly comparable levels of virus transfer and stability among the
319 different conditions (Fig. 6), implying that BCoV is also a suitable surrogate virus to
320 model surface transmission of SARS-CoV-2.

321

322 Decay of SARS-CoV2 is likely determined by a combination of the initial amount of
323 infectious virus deposited on a given surface and other environmental parameters
324 (temperature, humidity, light and UV conditions). Furthermore, persistence of pathogens
325 in the environment represents only the first requirement for self-inoculation via
326 contaminated fingers. However, the possibility of fingerprint transmission has
327 quantitatively been examined only in the context of bacteria [27]. Using a newly
328 developed virus touch transfer assay, we observed transfer of BCoV and SARS-CoV-2
329 between fomites and skin using a high initial virus titer ($\sim 10^6$ infectious virus particles).
330 This transfer was more efficient for the wet inoculum, while visual desiccation on the
331 one hand resulted in reduction of the titer as outlined above, as well as less efficient
332 mobilization of the viral particles, reflected by higher reduction factors. Consequently,
333 lower viral burdens ($\sim 10^4$ infectious virus particles) mimicking real life contamination
334 events more realistic, as observed for influenza viruses in aerosol particles from human
335 coughs [13,28], were not effectively transferred (Fig. 4 and 5). Recent studies estimated
336 a minimal infectious dose of SARS-CoV-2 in the range of 3×10^2 to 2×10^3 viral
337 particles [29]. Overall, our results point to a low risk of SARS-CoV-2 transmission by
338 coins and banknotes and the rush to abandon cash during the pandemic seems
339 unnecessary.

340 Given that cash is typically stored securely in wallets and purses, the risk of direct
341 contamination through exhaled droplets and aerosols seems much lower than constantly
342 exposed surfaces (e.g. doorbell, shopping carts). The role of a contagious person
343 contaminating banknotes and coins afresh when handing over, needs to be addressed in
344 future studies. Current government regulations to wear masks minimize the spread of
345 exhaled droplets and aerosols, and in combination with good hand hygiene also mitigate

346 the risk of transmission via contaminated surfaces. Still, contamination of cash is most
347 likely to occur indirectly by transfer from the hands of an infected person or finger
348 contact with a contaminated surface. However, any contamination by these routes would
349 likely result in a much lower degree of surface contamination than by direct
350 contamination as investigated in this study. Consequently, the overall chance of
351 transmission of SARS-CoV-2 through banknotes, coins and credit/debit cards seems low
352 since a timely order of specific events – sufficient viable virus deposited on a surface,
353 survival of the virus until the surface is touched, and transfer of an infectious dose of
354 virus – is required.

355

356 **Disclosure statement**

357 DT and ES receive consulting fees from the European Central Bank. FHB is executive
358 partner of Dr. Brill + Partner GmbH. DP and BB are employees at Dr. Brill + Partner
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370

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476

477 **Figure legends**

478 **Figure 1: Stability of BCoV on banknotes and steel discs.** BCoV stock solution was
479 applied on 2 cm × 2 cm pieces of 10 € or 50 € banknotes and recovered after the indicated
480 times. Residual titer was assessed via limiting dilution assay. **A)** Infectious BCoV
481 recovered, displayed as raw TCID₅₀/mL (y-axes) over time (categorical x-axes). Dots
482 indicate mean values of three independent experiments with standard deviation, lower
483 limit of quantification is shown as dashed line. **B)** Recovered BCoV displayed as
484 TCID₅₀/mL (y-axes) over time (continuous x-axes). Dots represent individual biological
485 experiments, purple lines and areas display the course of the Weibull distribution fitted
486 data and 95% confidence interval, lower limit of quantification is shown as dashed line.
487 Virus particles created with BioRender.com.

488

489 **Figure 2: Stability of SARS-CoV-2 on banknotes, coins and steel discs.** SARS-CoV-
490 2 stock solution was applied on 2 cm × 2 cm pieces of 10 € banknotes, 1 €, 10 cent and
491 1 cent coins and recovered after the indicated times. Residual titer was assessed via
492 limiting dilution assay. Humidity and temperature during experiments was logged
493 (32% - 43% RH, 22.4 °C – 23.2 °C) **A)** Infectious SARS-CoV-2 recovered, displayed as
494 raw TCID₅₀/mL (y-axes) over time (categorical x-axes). Dots indicate mean values of
495 three independent experiments with standard deviation, lower limit of quantification is
496 shown as dashed line. **B)** Recovered SARS-CoV-2 displayed as TCID₅₀/mL (y-axes)
497 over time (continuous x-axes). Dots represent individual biological experiments, green
498 lines and areas display the course of the Weibull distribution fitted data and 95%
499 confidence interval, lower limit of quantification is shown as dashed line. Virus particles
500 created with BioRender.com.

501 **Figure 3: Touch transfer assay setup.** To study the transfer of infectious BCoV and
502 SARS-CoV2 between finger pads and different fomites, 50 μ L virus suspensions are
503 placed on different surfaces (pieces of 10 € banknotes, 10 cent coins, pieces of PVC to
504 mimic the surface of credit cards and stainless-steel discs as reference) in 10 μ L spots.
505 Afterwards, the wet inoculum or the dried suspension is touched by “printing” or
506 “rubbing” using finger pads (BCoV) or an artificial skin fabric (SARS-CoV-2).
507 Subsequently, infectious virus was recovered by rubbing the fingertip on the bottom of
508 a petri dish filled with respective culture media or in case of the artificial skin directly
509 transferred into a container. The resulting suspension is serially diluted to determine
510 TCID₅₀/mL values of the remaining infectious virus. Virus particles created with
511 BioRender.com.

512
513 **Figure 4: Transferability of BCoV from cash fomites to fingertips.** Bars depict titer
514 of input virus suspension and recovered infectious virus from different cash fomites, i.e.
515 10 cent coin, 10 € banknote, pvc and steel disc carrier in four different scenarios. **A)**
516 High initial input titer ($\sim 10^6$ TCID₅₀/mL) wet, when directly touch after application and
517 dry, when transferred after visual desiccation and **B)** low initial input titer ($\sim 10^4$
518 TCID₅₀/mL), wet and dry. Each scenario was performed by three test persons using eight
519 fingers each. Numbers above bars indicate reduction factor, lower limit of quantification
520 is shown as dashed line.

521

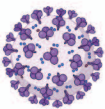
522

523

524 **Figure 5: Transferability of SARS-CoV-2 from cash fomites to fingertips.** Bars
525 depict titer of input virus suspension and recovered infectious virus from different cash
526 fomites, i.e. 10 cent coin, 10 € banknote, pvc and steel disc carrier in four different
527 scenarios; mean \pm SD. Humidity and temperature during experiments was logged
528 (32% - 43% RH, 22.4 °C – 23.2 °C) **A)** High initial input titer ($\sim 10^6$ TCID₅₀/mL) wet,
529 when directly touch after application and dry, when transferred after visual desiccation
530 and **B)** low initial input titer ($\sim 10^4$ TCID₅₀/mL), wet and dry. Numbers above bars
531 indicate reduction factor, lower limit of quantification is shown as dashed line. Virus
532 particles created with BioRender.com.

533
534 **Figure 6: Suitability of BCoV as surrogate for SARS-CoV-2 in touch transfer**
535 **studies.** Titers of recovered infectious virus were matched between BCoV and SARS-
536 CoV-2 for each scenario and linear regression curves calculated for input, rub and print.
537 Gray line and area represent the overall linear regression and 95% confidence interval
538 of all matched data points, dashed line depicts perfect correlation.
539
540

BCoV



bank notes

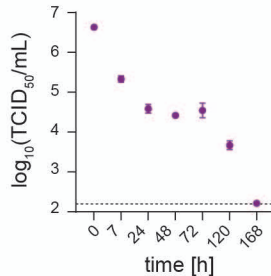
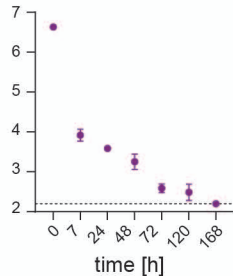
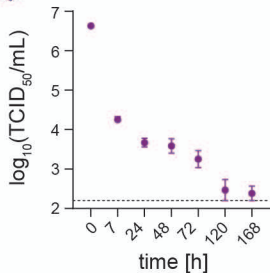
control

10 euro

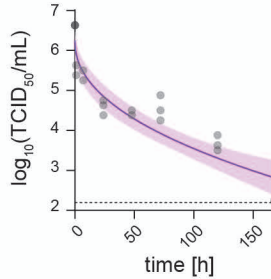
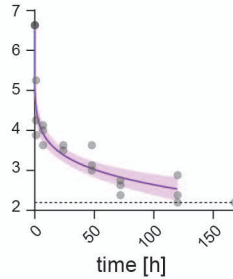
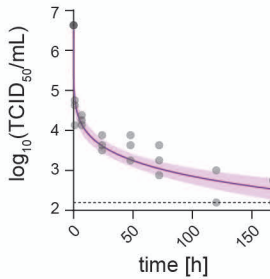
50 euro

steel disc

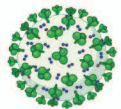
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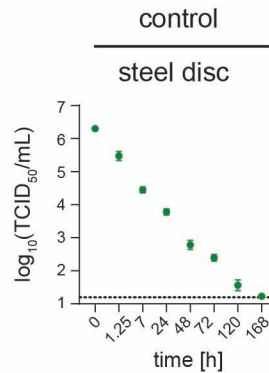
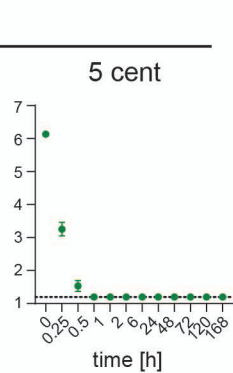
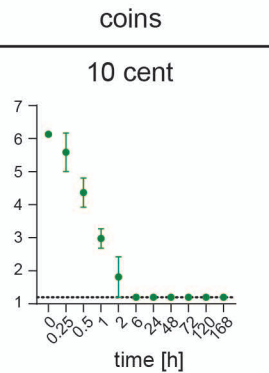
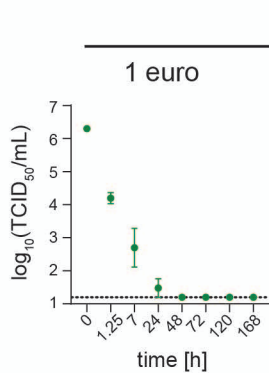
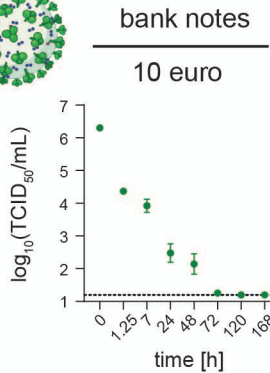
B)



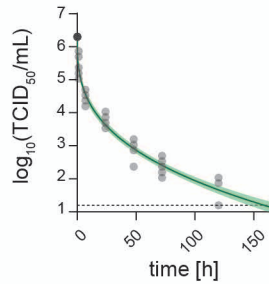
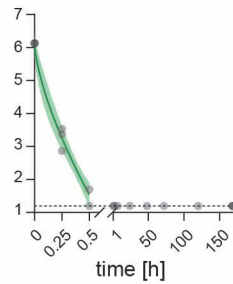
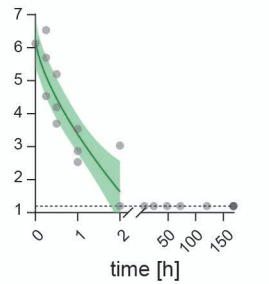
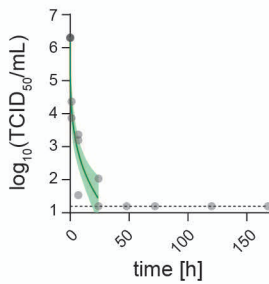
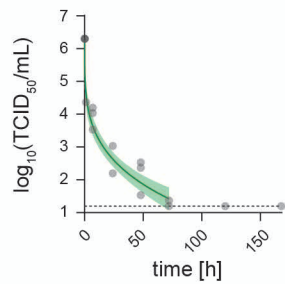
SARS-CoV-2



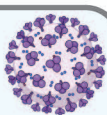
A)



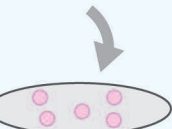
B)



BCoV



carrier



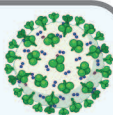
wipe off



limiting dilution
assay

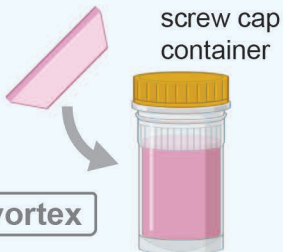


SARS-CoV-2



artificial skin

frame

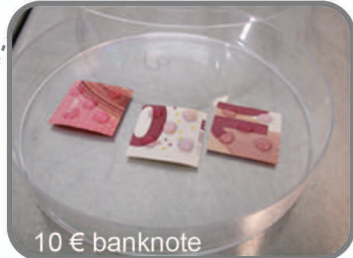


screw cap
container

vortex



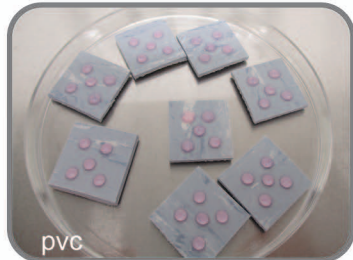
limiting dilution
assay



10 € banknote



10 c coin

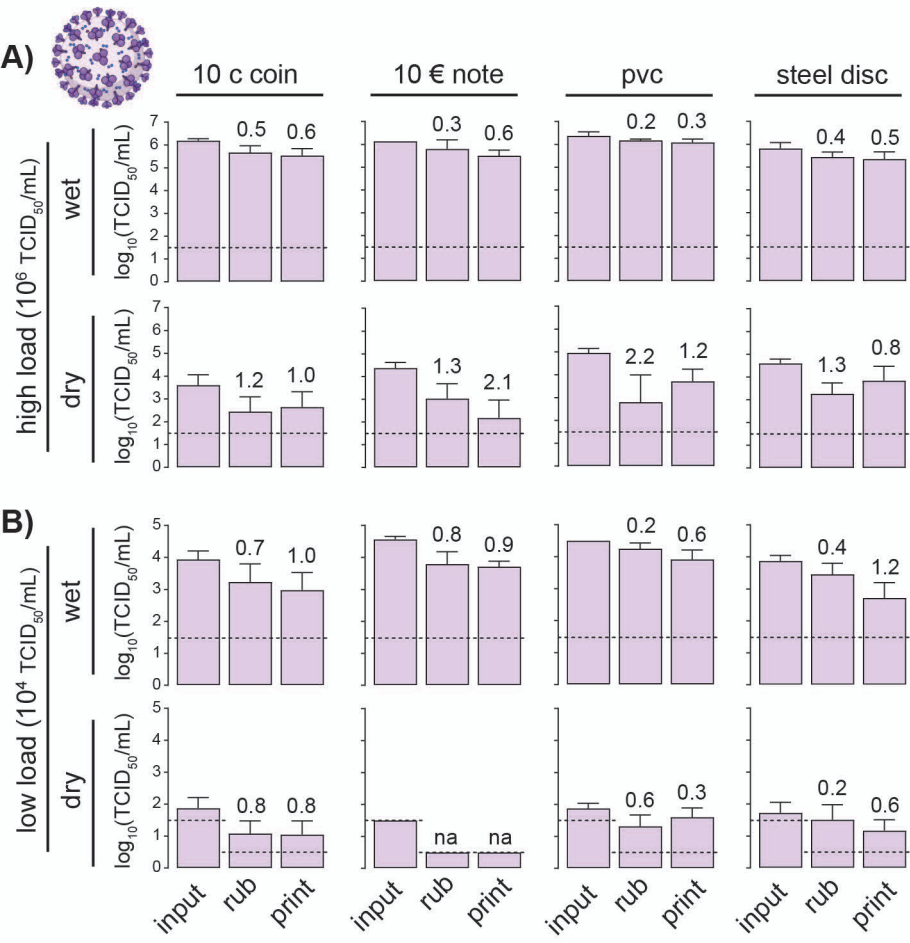


pvc

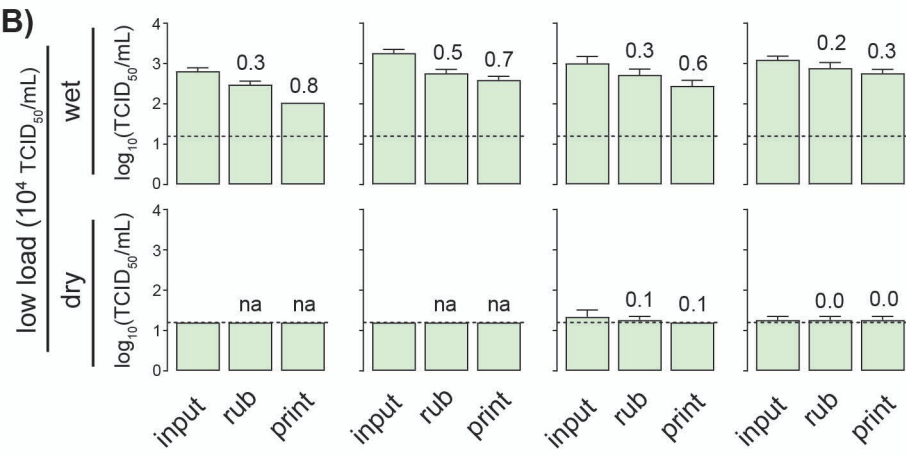
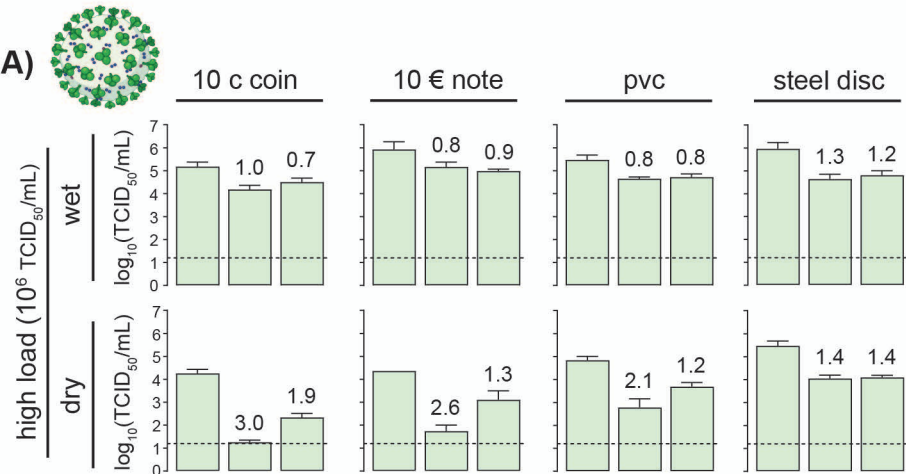


stainless steel

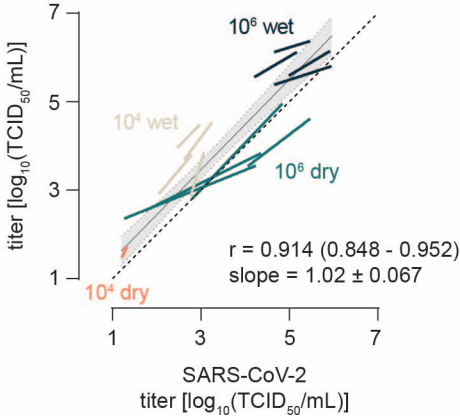
BCoV



SARS-CoV-2



BCoV



		SARS-CoV-2		BCoV	
	material	initial decay [h]	time to LLOQ [h]	initial decay [h]	time to LLOQ [h]
notes	50 euro			2.8	175.6
	10 euro	6.1	85.7	6.5	216.3
coins	1 euro	2.2	28.4		
	10 cent	0.8	2.3		
	5 cent	0.2	0.6		
control	steel disc	20.6	158.8	53.5	240.2