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Adherence to stay-at-home orders: awareness, implementation and difficulties of the officially ordered quarantine measures in the context of the SARS-CoV2 pandemic in Cologne - a cross-sectional cohort study

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Adherence to stay-at-home orders: awareness, implementation and difficulties of the officially ordered quarantine measures in the context of the SARS-CoV2 pandemic in Cologne - a cross-sectional cohort study

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ABSTRACT

Objectives:
To estimate the awareness, implementation and difficulty of behavioural recommendations and their influencing factors in officially ordered domestic isolation and quarantine during the Covid-19 pandemic.

Design:
Online cross-sectional cohort survey conducted from 12.12.2020 to 6.1.2021 as part of the CoCo-Fakt study (Cologne-Corona Counselling and Support for Index- and Contact Persons during the Quarantine Period).

Setting:
Administrative area of the City of Cologne, Germany

Participants:
3011 infected persons and 5822 contacts over 16 years of age who were in officially ordered domestic isolation or quarantine between 28.02.2020 and 09.12.2020. Of these, 60.4% were females.

Outcome measures:
Based on the responses on awareness and implementation of 19 behavioural recommendations, scores were calculated to determine community- and household-based adherence. Linear regression analyses were conducted to determine factors influencing adherence.

Results
The average adherence to all recommendations, including among others, staying in a single room, keeping distance and wearing a mask was 92.8% and 68.8% for community-based recommendations (CBRs) and household-based recommendations (HBRs), respectively. Infected persons were significantly more adherent to CBRs (95.3% vs. 91.2%; p<.001) and HBRs (72.9% vs. 66.0%; p<.001) than contact persons. Among other factors, both status as an infected person and being informed about the measures in a comprehensible way had positive influences on participants' adherence. The linear regression analysis explained 6,6% and 14,4% (corr. R^2) of the adherence to HBRs and CBRs.

Conclusion
Not all persons under official quarantine were aware of the relevant behavioural recommendations. This was especially true in cases where instructions were given for measures to be taken in one's own household. Due to the high transmission rates within a household, HBRs should therefore be communicated with particular emphasis. In counselling citizens, care should also be taken to ensure that those affected understand how they should behave during quarantine and why these measures are meaningful.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- A large, homogenous cohort of participants in officially ordered isolation and quarantine, a subgroup among witch studies on adherence are lacking.

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- Detailed consideration of the various recommendations in domestic isolation and quarantine, taking motivation into account
- This survey was limited to the catchment area of the Cologne Health Department, Germany.
- Selection bias due to the online format of the survey.
- Non-compliance with the officially ordered isolation and quarantine measures is a punishable offence in Germany. Even though the anonymity of participation was explicitly mentioned in our survey, it cannot be ruled out that this led to desired and less honest answers.

INTRODUCTION

Alongside vaccination, non-pharmaceutical interventions such as restrictions in public life, social distancing and, in particular, the isolation of people infected with Covid-19 (infected persons = IPs) and the quarantine of their close contacts (contact persons = CPs) continue to constitute a central pillar in the control of Covid-19 in many countries.[1] It is undisputed that the effectiveness of the quarantine measures is largely dependent on the adherence of the persons concerned.[2, 3] In studies of previous pandemics, this effectiveness varied considerably (between 0 and 92.8%) and depended not only on financial security and sufficient food supply, but also on an understanding of the required measures and the perception of social pressure.[2] Previous studies on adherence to social distancing measures in the Covid-19 pandemic yielded findings ranging from 87% adherence[4] to 92.8% non-adherence[5], but they are hardly comparable with each other due to very different questionnaire items and assessment criteria. In summary, it was found that women consistently achieved higher adherence scores than men, and that older people and people with higher levels of education or socioeconomic status (SES) were more likely to implement the interventions than younger people or those with lower levels of education or SES.[4–9]

The aforementioned studies mainly addressed general social distancing measures and self-isolation; adherence to officially ordered isolation and quarantine was hardly investigated. IPs and CPs have a particularly high potential for infection. Before the start of vaccinations, the household secondary attack rate was 16.6%, and during the course of vaccinations, at least one infection occurred in 31.7% of multi-person households.[10] In a Norwegian cohort study, almost 1900 people with positive Covid-19 tests were identified from August to October 2020. Among them, 79% of the men and 91% of the women reported isolation.[11] In a UK cohort study that included a total of 1213 people with Covid-19 suspected symptoms, only 42.5% reported not leaving the house in the 10 days after symptom onset. In this context, women, the elderly and subjects with lower education levels, higher SES and no dependent children in the household were more adherent[12]. Verberk et al. also examined households' levels of implementation of recommendations in a small study of 34 households, each with an index case. While in a majority of the households, staying in the same room with the IP was avoided and ventilation was more frequent, wearing masks in the household was more often not considered useful and not implemented.[13]

Although Covid-19 vaccination significantly reduces infection rates and infectivity of those affected, isolation and quarantine measures continue to be highly valued responses to the pandemic in the context of emerging variants of concern and reduced vaccine efficacy against these variants.[14, 15] Knowledge about the general level of awareness and implementation

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of various measures, and of possible factors influencing awareness and implementation, is therefore essential. Within the CoCo-Fakt cohort study (Cologne-Corona Counselling and Support for Index- and Contact Persons during the Quarantine Period), IPs and CPs in the area of responsibility of the Cologne Health Department, the largest health department in Germany, were surveyed regarding their adherence to quarantine measures following an officially ordered domestic quarantine. In addition to awareness and implementation of the respective behavioural recommendations, the study investigated the difficulties experienced during implementation and the individual factors associated with adherent or non-adherent behaviour.[14, 16]

METHODS

Study design

The CoCo-Fakt study examined a cohort of IPs and their relevant CPs, who had been quarantined by Cologne's local health authorities since the beginning of the SARS-CoV-2 pandemic in February 2020. The questionnaire was developed and modified based on the COVID-19 Snapshot Monitoring questionnaire from the University of Erfurt (COSMO) and carried out with the online survey software Unipark.[17] Ethics approval was obtained from the Rheinisch-Westfälische Technische Hochschule Aachen Human Ethics Research Committee (351/20); see Joisten et al.[16] Responding to the questionnaire took approximately 30 minutes, and qualitative data were evaluated using MAXQDA software. The survey was conducted from 12.12.2020 to 6.1.2021.

Sampling and study population

Approximately 1,083,000 citizens fall under the jurisdiction of the Cologne Health Department. Starting in February 2020, IPs and CPs were contacted on the telephone by trained staff from the Cologne Health Authority and questioned in a standardised interview regarding their symptoms, possible routes of infection, chronic diseases, risk factors and residential and family situations.[14] These individuals were quarantined based on the legal regulations for combating infectious diseases according to the Infectious Diseases Protection Act (German 'Infektionsschutzgesetz', or, IfSG), with the usual length of quarantine for IPs being 14 days after symptom onset or a positive test result. The quarantine period for CPs was 10–14 days at the time of this survey, depending on the time of last contact. Until October 2020, this period could be extended, lasting for several weeks in families that could not be physically separated. All data were recorded using the Cologne Health Authority's specially programmed software, the digital contact management system (DiKoMa).[18]

From February 28 (first case in Cologne) to December 9, 2020, all persons who were at least 16 years old, registered in DiKoMa with a positive SARS-CoV-2 test (quantitative real-time polymerase chain reaction) and whose informed consent was obtained were integrated into this analysis along with their relevant CPs. Contacts who tested positive for SARS-CoV-19 during quarantine were included in the infected group.

Sampling and study population

36498 persons whose email addresses were known could be identified in DiKoMa during the period under consideration. Of these, 33699 persons were sent the questionnaire and 13057 clicked on the questionnaire. Pregnant women who were monitored and advised particularly intensively by the Cologne Health Department during the study period, persons under 16 years

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of age, subjects with missing or invalid essential information (sex, age, awareness of quarantine recommendations 1–3) as well as subjects who could not be assigned to the IP and CP groups (e.g. travel returnees) were excluded (N=3462). Thus, 9595 subjects (3773 IPs and 5822 CPs) were included in the analyses of adherence to community-based recommendations (CBRs). Household-based-recommendations (HBRs) were relevant only for those individuals who needed to isolate themselves from others within a household. Therefore, individuals for whom this did not apply, such as those living alone or in cohort isolation, were not included in the analysis of household-based adherence (N=5584). A total of 3011 subjects (1197 IPs, 1814 CPs) were included in the analysis of household-based adherence (Fig. 1).

Survey items

Demographic parameters and personal living situations

In addition to age, gender, migration background (yes/no) and relationship status (single/partnered), respondents were asked whether they had chronic illnesses (yes/no), had children (yes/no), lived alone (yes/no) or had access to a garden or balcony (yes/no). Socioeconomic status (SES) was determined based on the classifications of the German Health Update 2009.[19]

Quarantine recommendations: awareness, implementation and difficulties

A total of 19 recommendations for action relevant to isolation and quarantine for Covid-19 IPs and CPs were identified from the recommendations provided by the WHO, the European Centre for Disease Prevention and Control, the Robert Koch Institute (RKI) and the German Society for General and Family Medicine (Table 1).[20–23]

Table 1: Behavioural recommendations in domestic quarantine and isolation. The evaluations of recommendations 1–4, 7, 8, 14 and 16 (bold), which the authors consider particularly relevant, are dealt with in the paper and included in the calculation. CBR: Community based recommendation HBR: Household based recommendation

No.	Recommendation	
1	**Do not leave your home.**	**CBR**
2	**Do not receive visitors.**	
3	**Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.**	
4	**Stay apart from other household members in a single room.**	**HBR**
5	Sleep separately from other household members in a single room.	
6	Have contact with other household members only when you need their help.	
7	**Keep at least a 1.5m distance when in contact with other household members.**	
8	**Wear a mouth-nose mask when in contact with other household members.**	
9	Take your meals in a different room from other household members.	
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	
11	Use only one toilet. The rest of the household members should not use this toilet.	
12	The bathroom you use should be cleaned at least once a day.	
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	
14	**Air all rooms regularly.**	
15	Sneeze into the crook of your elbow or a disposable handkerchief.	
16	**Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.**	

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17	Collect tissues, gloves and other rubbish in a lidded bin in your room.
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.

Of these, three recommendations (do not receive visitors, stay at home and have no contact with delivery or postal workers) relate to seclusion from the public and are relevant for all persons in quarantine (community-based recommendations, or, CBRs). The other 16 recommendations relate to seclusion within a household and are only relevant to people who need to isolate themselves from other household members, but not to people living alone, or to index people in cohort isolation (household-based recommendations, or, HBRs). To identify subjects for whom HBRs are relevant, the item, 'Did you have to isolate yourself from other household members during your quarantine? (yes/no)' was included in the questionnaire.

CBRs 1–3 were presented to all participants. The HBRs were presented only to subjects who indicated that they had to isolate themselves from other household members. Recommendation 11 (use of a separate toilet) was also presented only to subjects who had previously reported living in a household with more than one toilet. For each recommendation presented, the respondents were first asked whether the respective recommendation was known (yes/no). If the recommendation was known, they were also asked to what extent it had been implemented and how difficult it was to implement. The survey was carried out using a 6-part interval scale with endpoints 1 ≙ I have not implemented at all 6 ≙ I have fully implemented, and 1 ≙ I have found this very difficult 6 ≙ I have not found this difficult at all.

Whereas at the beginning of the Covid-19 pandemic, droplet and smear infection were considered the main transmission routes, respiratory ingestion of virus-containing particles in the form of aerosols has been identified as the most important transmission route in the further course of the pandemic.[24] In the present paper, the CBRs on staying in a single room, regular ventilation, wearing a mouth-nose covering, keeping a distance of 1.5 m from other persons and hand hygiene, which are considered particularly relevant for the prevention of aerosol transmission and are promoted in an extensive public campaign by the German Federal Ministry of Health, are considered in more detail.[25] Evaluations of other recommendations can be found in the supplement (Tables S1-3).

Adherence scores

Baseline adherence score

A baseline adherence score was calculated to map individual adherence and examine influencing factors. The basis for this baseline adherence score was the awareness and implementation of the particularly important CBRs 1–3.

According to the answers on the 6-part scale for the implementation of the recommendations, each respondent received points from 0 (not implemented at all) to 5 (fully implemented) for each of the three recommendations. If the recommendation was not known, or if the respondent did not provide information on implementation, 0 points were awarded. With three recommendations scored, the maximum possible score is 15, corresponding to a baseline adherence score of 100%.

Household adherence score

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Following the same procedure, a household adherence score was calculated including HBRs 4, 7, 8, 14 and 16 for all subjects who had to isolate themselves from other household members. Missing answers, including the answer 'I did not implement at all', were weighted with 0 points. With five recommendations scored, the maximum possible score is 25, corresponding to a household adherence score of 100%.

Views on Covid-19 in relation to quarantine

Based on the mechanisms for motivation and implementation of preventive health measures described by Rosenstock in the Health Belief Model[26], 11 statements or questions adapted to the Covid-19 pandemic were formulated:

- 'I have been given clear information about the reason for the isolation/quarantine.'
- 'It was explained to me in an understandable way how to behave in isolation/quarantine.'
- 'People in my professional and social environment have expected me to implement the quarantine measures.'
- 'I think the coronavirus is dangerous.'
- 'When I isolate/quarantine myself, I am protecting myself.'
- 'When I isolate/ quarantine myself, I am protecting other members of my household.'
- 'When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus.'
- 'I experienced difficulties in obtaining everyday necessities during isolation/quarantine.'
- 'I suffered financial losses due to the isolation/quarantine.'
- 'I think the isolation/ quarantine measures are too strict.'
- 'I think the quarantine measures are too lax.'

Respondents' agreement with each statement was determined using a 6-item endpoint-named interval scale (strongly disagree–strongly agree). For the question regarding financial losses due to quarantine, the answer was binary (yes/no). The allocation of these statements to the relevant factors of the heath-believe model is presented in the supplement (Table S4).

Data analysis

Descriptive and inductive data analyses were conducted using the programme SPSS 28.0 (IBM, Armonk, NY, USA). Chi-square tests and t-tests were conducted to assess the differences between IPs and CPs.

Linear backward regression analyses were conducted to determine the influence of age (in years), quarantine as an IP (1) or CP (2), gender (female = 1, male = 2), being in a partnership (no=1, yes = 2), living situation with balcony or garden (yes = 0, no = 1), migration background (no=1, yes=2), Socioeconomic status (high=1, middle and low=2), Comorbidity (yes=1, no=2), presence of children in the household (yes=1, no=2) well as the hypothetical influencing factors on baseline and household adherence scores listed above (Table S1) (agree=1; disagree=2). Non-significant factors were excluded during stepwise regression. A p-value below 0.05 was considered significant.

Patient and Public Involvement

The research questions and methods were developed based on the literature. In order to optimize the survey and align it according to the research questions, affected persons from

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the personal environment were first approached and asked to answer and assess the draft. From this collective, 20 additional affected persons were then recruited by snowball sampling and the feasibility and duration were tested. Since the online survey is anonymized, no individual results are given to the patients (see Joisten et al. 2021[16]). But future quarantined persons should benefit from our study.

RESULTS

Demographic parameters and personal life situation

The participants in the study were on average 40.9 years old (SD=14.2), and 63% were women. The data for the total group and data subdivided according to IP and CP are shown in Table 2.

*Table 2: General characteristics of participants, total and by status as infected person or contact person; * chi-2-test; **unpaired t-test*

Variable	Total N (%)	Infected persons N (%)	Contact persons N (%)	p-Value
Sample	9595 (100)	3773 (39.3)	5822 (60.7)	
Sex	9595 (100)			
Male	3797 (39.6)	1643 (43.5)	2154 (37.0)	<.001*
Female	5798 (60.4)	2130 (56.5)	3668 (63.0)	
Mean age years (SD)	40.9 (14.2)	41.9 (14.3)	40.3 (14.1)	<.001**
Age Groups (years)	9595 (100)			
16-29	2580 (26.9)	925 (24.5)	1655 (28.4)	<.001*
30-39	2260 (23.6)	853 (22.6)	1407 (24.2)	
40-49	1771 (18.5)	731 (19.4)	1040 (17.9)	
50-59	1953 (20.4)	812 (21.5)	1141 (19.6)	
60-69	789 (8.2)	339 (9.0)	450 (7.7)	
70+	242 (2.5)	113 (3.0)	129 (2.2)	
Migration background	9427 (100)			
No	8919 (94.6)	3421 (92.8)	5498 (95.8)	<.001*
Yes	508 (5.4)	265 (7.2)	243 (4.2)	
Socioeconomic Status (SES)	9522 (100)			
High	7644 (80.3)	2964 (79.2)	4680 (61.2)	.007*
Middle	1790 (18.8)	731 (19.5)	1059 (59.2)	
Low	88 (0.9)	47 (1.3)	41 (0.9)	
Married/ living in a Relationship	9383 (100)			
No	2650 (28.2)	1012 (27.5)	1638 (28.7)	.186*
yes	6733 (71.8)	2671 (72.5)	4062 (71.3)	
Having children	9553 (100)			
No	5419 (56.7)	2070 (55.2)	3349 (57.7)	.013*
Yes	4134 (43.3)	1683 (44.8)	2451 (42.3)	
Living alone	9545 (100)			
No	6767 (70.9)	2656 (70.8)	4111 (70.9)	.905*
Yes	2778 (29.1)	1094 (29.2)	1684 (29.1)	
Access to balcony or garden	9557 (100)			
No	1443 (15.1)	530 (14.1)	913 (15.7)	.030*
Yes	8114 (84.9)	3226 (85.9)	4888 (84.3)	
Comorbidity	9264 (100)			
No	7212 (77.8)	2768 (76.2)	4444 (78.9)	.003*
Yes	2052 (22.2)	863 (23.8)	1189 (21.1)	

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Baseline adherence score

The mean baseline adherence score was 92.8% (SD=15.7%). Only 0.7% (N=68) of respondents did not observe any of the CBRs, obtaining a score of 0%. Of the respondents, 70.8% fully implemented the included recommendations, corresponding to a baseline adherence score of 100%. IPs achieved a significantly higher adherence score than CPs (95.3% +/-13% vs 91.2% +/-17%; p<.001). In total, 64.9% of contacts and 80.0% of index subjects achieved a baseline adherence score of 100%. The detailed distribution of the baseline adherence score is shown in the supplement (Table S5).

Household adherence score

The mean household adherence score was 68.8% (SD=27.0%). Of the respondents, 2.2% (N=67) did not observe any of the HBRs, obtaining a score of 0%, whereas 18.2% fully implemented all included recommendations, corresponding to a household adherence score of 100%. IPs achieved a significantly higher adherence score than did CPs (72.9% +/-26.6% vs 66.0% +/-27%; p <.001). In total, 22.8% of IPs and 15.1% of CPs achieved a household adherence score of 100%. The detailed distribution of the household adherence score is shown in the supplement (Table S6).

Awareness of the recommendations

Results showed that 88.8% of all respondents, 92.2% of IPs and 86.6% of CPs, were aware of all three CBRs (stay at home, do not receive visitors and have no contact with delivery or postal workers). On average, 2.9 of the CBRs were known to the IPs and 2.8 were known to the CPs (p <.001). While 98.7% of respondents were aware of the recommendation not to receive visitors, and 98.3% were aware of the recommendation not to leave home, only 90.1% were aware of the recommendation not to have contact with delivery or postal workers.

The awareness of the 16 HBRs varied more markedly. On average, 71.6% of the HBRs were known to all subjects, 75.7% to the IPs and 68.9% to the CPs. For example, only 33.2% of respondents were aware of the recommendation to wash laundry separately and at 60°, and only 41.1% knew about the recommendation to dispose of waste in a separate waste bin. On the other hand, 97.7% and 95.1% of the respondents stated that they were aware of the recommendations on coughing and sneezing etiquette and hand hygiene, respectively. While the recommendations on regular hand hygiene (IP: 94.6%; CP: 95.4%), staying in a single room (IP: 93.8%; CP: 88.8%), regular ventilation (IP: 91.9%; CP: 90.3%) and keeping a distance of 1.5m (IP: 88.6%; CP:83.6%) were widely known, the recommendation to wear a mouth-nose covering inside their house or flat was less well known, especially among CPs (IP:74.0%; CP: 63.1%) (Table S1).

Implementation of the recommendations

On the 6-item endpoint-named interval scale for implementation of interventions, all CBRs achieved very high mean scores that ranged between 5.9 and 6.0 among IPs. CPs implemented the HBRs to a somewhat lesser degree, obtaining mean scores between 5.8 and 5.9. The HBRs on regular ventilation (IP: 5.7 CP: 5.6) and hand washing (IP: 5.7 CP: 5.7) were quite well implemented, with no appreciable differences between IPs and CPs here. Comparatively worse, with mean values of 4.9–5.2 (IPs) and 4.4–4.7 (CPs), were the HBRs on staying in a single room, keeping a distance of 1.5m and wearing a mouth-nose mask. These recommendations, which involve distancing oneself from other household members, were implemented significantly better by the IPs than by the CPs (see Figure 2 and Table S2).

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Difficulties of implementation

The greatest implementation difficulties were found in the recommendations requiring distancing from familiar people. The most problematic was the implementation of seclusion in a single room, with mean scores of 2.9 among IPs and 2.6 among CPs. The recommendations to wear a mouth-nose covering (IP: 4.4; CP: 3.9), keep a distance of 1.5m (IP: 3.8; CP: 3.4), avoid visitors (IP: 4.7; CP: 4.2) and stay at home (IP: 4.2; CP: 3.6) were also comparatively difficult to implement. In contrast, the recommendations on regular hand washing (IP: 5.6; CP: 5.6), airing (IP: 5.6; CP: 5.5) and avoiding contact with delivery and postal workers (IP: 5.6; CP:5.5) were easy to implement (see Figure 2 and Table S3).

Views on isolation and quarantine for Covid-19

The majority of subjects (74.9%) agreed or strongly agreed with the statement that they had been given clear information about the reason for their isolation/quarantine. Moreover, 70.1% stated that they had also been given clear information about how to behave during isolation/quarantine. Both statements attained significantly higher agreement values among IPs than among CPs (with mean values of 5.3 and 5.1, respectively, versus 4.8 and 4.7, respectively; p<.001). Of all respondents, 86.2% considered the coronavirus to be dangerous, and 95.3% agreed or fully agreed with the statement that quarantine measures would protect society from further spread of the coronavirus; however, only 61.4% agreed with the statement that isolation measures would protect other household members. A high percentage of respondents (84.9%) assumed that people around them expected them to comply with the quarantine measures. A lower percentage (18.8%) stated that they had suffered financial losses due to the isolation/quarantine (79.3% no losses, 1.8% prefer not to say). A low percentage of respondents (15.4%) also stated that they experienced difficulties in obtaining everyday necessities during isolation/quarantine (see Table S4).

Factors influencing adherence during isolation and quarantine

Regression analysis was used to determine factors influencing baseline adherence scores. The Baseline models are shown in the supplement (Table S7). The final models are shown in Table 3. A total number of 7173 subjects were included in the regression analysis of the baseline adherence score. Factors correlating with higher baseline scores include status as an IP (β=-0.102; p<.001), older age (β=0.055; p<.001), presence of children in the household (β=-0.037; p=.008) and agreement with the following statements: 'It was explained to me in an understandable way how to behave in quarantine' (β=0.136; p<.001), 'When I isolate/ quarantine myself, I am protecting other members of my household' (β=0. 046; p<.001), 'When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus' (β=0.049; p<.001) and 'People in my professional and social environment have expected me to implement the quarantine measures' (β=0.069; p<.001). Agreement with the statements that the isolation/quarantine measures were too strict (β=-0.049; p<.001), too lax (β=-0.033; p=0.004) or that there were supply difficulties during isolation/quarantine (β=-0.042; p<.001) was associated with a lower baseline adherence score. The model explained 6.6% (corr. R^2) of the variance.

Factors influencing household adherence scores were analysed analogously (see supplement Table S7 and Table 3). A total number of 2227 subjects were included in the regression analysis of the household adherence score. Here, factors correlating with higher household adherence scores included IP status (β=-0.103; p<.001), older age (β=0.108; p<.001), male gender

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(β=0.043; p=0.030), migration background (β=0.058; p=.004), lower SES (β=-0.045; p=0.025), living in a relationship (β=0.099; p<.001), having children in the household (β=-0.058; p=0.028), considering coronavirus dangerous (β=0.052; p=0.011) and agreement with the following statements: 'I have been given clear information about the reason for the isolation/quarantine.' (β=0. 060; p=0.014), 'It was explained in an understandable way how to behave in isolation/quarantine' (β=0.047; p=0.051), 'When I isolate/ quarantine myself, I am protecting other members of my household.' (β=0.240; p<.001) and 'When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus' (β=0.037; p=0.072). In addition, there was a positive association between financial losses due to quarantine and household adherence (β=-0.034; p=0.090). The model explained 14,4% (corr. R^2) of the variance.

*Table 3 Factors influencing the baseline and household adherence score. Final models of linear backward regression analyses *(disagree=1; agree=2)*

Final models	Non-Standardised Coefficients		Standardised Coefficients	Sig.	95% Confidence Interval	
	Regression Coefficient (B)	Std. Error	Beta		Lower Limit	Upper Limit
Baseline adherence score						
Infected persons (1) vs. Contact persons (2)	-0.030	0.003	-0.102	<.001	-0.037	-0.024
Age (years)	0.001	<0.001	0.055	<.001	<0.001	0.001
Having Children (yes=1; no=2)	-0.011	0.004	-0.037	.008	-0.019	-0.003
It was explained to me in an understandable way how to behave in quarantine. *	0.051	0.004	0.136	<.001	0.043	0.060
I think the isolation/ quarantine measures are too strict. *	-0.016	0.004	-0.049	<.001	-0.024	-0.009
I think the isolation/ quarantine measures are too lax. *	-0.011	0.004	-0.033	.004	-0.019	-0.004
When I isolate/ quarantine myself, I am protecting other members of my household. *	0.015	0.004	0.046	<.001	0.007	0.022
When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus. *	0.049	0.013	0.045	<.001	0.024	0.073
People in my professional and social environment have expected me to implement the quarantine measures. *	0.037	0.006	0.069	<.001	0.025	0.049
I experienced difficulties in obtaining everyday necessities during isolation/quarantine *	-0.014	0.004	-0.042	<.001	-0.022	-0.006
Household adherence score						
Infected persons (1) vs. Contact persons (2)	-0.052	0.010	-0.103	<.001	-0.072	-0.032
Age (years)	0.002	<0.001	0.108	<.001	0.001	0.003
Sex (female=1; male=2)	0.022	0.010	0.043	.030	0.002	0.042
Migration background (no= 1; yes=2)	0.064	0.022	0.058	.004	0.021	0.107
Socioeconomic status (SES) (high=1; middle and low=2)	-0.028	0.012	-0.045	.025	-0.052	-0.004
Married/ living in a Relationship (no=1; yes=2)	0.062	0.014	0.099	<.001	0.035	0.090

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Having Children (yes=1; no=2)	-0.029	0.013	-0.058	.028	-0.054	-0.003
I think the coronavirus is dangerous. *	0.059	0.023	0.052	.011	0.014	0.104
I have been given clear information about the reason for the isolation/quarantine. *	0.042	0.017	0.060	.014	0.009	0.076
It was explained to me in an understandable way how to behave in quarantine. *	0.031	0.016	0.047	.051	<0.001	0.063
When I isolate/ quarantine myself, I am protecting other members of my household. *	0.145	0.012	0.240	<.001	0.121	0.169
When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus. *	0.074	0.041	0.037	.072	-0.007	0.154
I suffered financial losses due to the isolation/quarantine (yes=1; no=2)	-0.021	0.012	-0.034	.090	-0.045	0.003

DISCUSSION

To our knowledge, this study is one of the first studies in Germany of adherence to recommendations while in official domestic isolation or quarantine during the Covid-19 pandemic. The study showed that the measures for seclusion from the public were especially well implemented with a mean adherence of 92.8%. Adherence to measures requiring distancing from other household members was lower, at 68.8%. The measures calling for seclusion in a single room and keeping a distance of 1.5 m from other household members were both particularly difficult to implement. By contrast, regular airing and washing of hands, as well as avoiding contact with delivery and postal workers, were easier.

Non-influenceable factors, including demographic factors such as gender, age, education level and status as an IP, affected levels of adherence. In the present study, men were more adherent than women, older people more adherent than younger people and IPs more adherent than CPs. Al-Hanawi et al., Al-Zabadi et al. and Park et al. also showed higher adherence among older people in survey studies on the implementation of social distancing measures in the general population, as did Smith et al. in a study on self-isolation at the onset of Covid-19 symptoms in a British cohort. [4, 12, 27, 28] However, in all four studies, women were more likely to implement the relevant measures. Why men performed better on HBRs in our study can only be speculated here. As the Mannheim-Corona study by Blom et al. suggests, women (still) feel more obliged to take on household tasks even during quarantine.[29] Smith et al. showed lower adherence in their study among subjects with younger children in the household. However, the only criterion for adherent behaviour in their study was whether the subjects left their home.[12] Our study found a positive correlation between the presence of children in the household and greater adherence, accounting for all relevant isolation/quarantine recommendations. Subjects with children in the household implemented the HBRs significantly better than did subjects without children at home. The reason for this could be the high motivation of many parents to protect their children from infection.

In addition, it was shown that individual and, above all, influenceable perceptions affected adherence. According to Rosenstock's Health Belief Model for predicting health-related behaviour, in addition to the perceived risks associated with a given disease, the assumed costs and benefits of different behaviours also have an influence on the extent of behavioural

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change.[26] Subjects who stated that they had been clearly informed about both the reason for their isolation or quarantine and the scope of the measures mandated, showed greater adherence to the measures. Adherence was also positively influenced by the assessment of the measures as appropriate, as well as the perception of social pressure in relation to their implementation. The perception that Covid-19 is dangerous had a further positive influence on household adherence. In cross-sectional studies of perceptions of the coronavirus and social distancing measures, Hills et al. and Al Sabbagh et al. found that the perceived dangerousness of infection and identifying oneself as belonging to a risk group were both associated with higher adherence.[5, 30] While Al Sabbagh et al. also found that a perceived financial disadvantage related to social distancing measures correlated with lower adherence, the present study associated higher expenditures or financial losses due to isolation or quarantine with higher household adherence.[30] This fact could be explained by a certain retrospective aspect of our study: Those who adhered more strictly to the measures may – as a result – have had higher costs, e.g. for hygiene items or delivery services.

Strengths and limitations

A particular strength of this survey was the large, homogeneous cohort and the detailed consideration of the various recommendations, taking motivation into account. Even though this survey was limited to the catchment area of the largest health department in Germany, the measures were largely uniform across Germany, and the approaches taken by the various health departments were comparable. This makes it quite likely that the findings can reliably be transferred to other urban regions. One limitation, however, was the online format, which could have prevented older participants, particularly those who are less computer-savvy, from participating. However, the average age of the study participants, at 40.9 years, is 13 months below the average age of the Cologne population.[31] Furthermore, when interpreting the results, it must be taken into account that citizens placed under isolation/quarantine orders were informed that non-compliance with certain measures, especially leaving one's own home, could be punished. Even though the anonymity of participation was explicitly mentioned in our survey, it cannot be ruled out that the threat of punishment led to desired and less honest answers. Moreover, it is plausible that more of those who complied with the prescribed measures took part in the survey.

CONCLUSIONS

In summary, adherence was quite high overall, especially with regard to the general isolation/quarantine rules. However, with high infection rates in households with an index case in the past and the comparatively lower adherence to isolation and quarantine within one household found in this study, it still seems sensible to develop more strategies for increasing adherence, particularly within households.[10] The pandemic has been ongoing for more than two years, and with the emergence of new viral variants such as Omicron, an associated weakened vaccine effectiveness and a still-significant number of unvaccinated people, the importance of non-drug measures is clear. As Telenti et al. have indicated, responsible management of Covid-19 will continue to be relevant in the future.[32] Thus, to support staff in health offices in their care of citizens, adequate education on the benefits of quarantine measures should be implemented in the public sphere. This might also lead to an increase in adherence, especially within a household. The approach to successful risk communication outlined by Loss et al, which include credible messages, acknowledgement of uncertainties and a balance of reassurance and alarm, combined with continuous monitoring

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and evaluation, could be used as a guide in order to prevent fatigue in future pandemics and in the ongoing development of Covid-19.[33]

Author Contributions
CJ, AK, JN and GAW conducted the study on behalf of the CoCo-Fakt study group, JB conducted the questions regarding the quarantine recommendations, CJ and JB conducted the statistical analyses, AK, CJ and JB contributed to interpreting the results, JB wrote the original draft of the manuscript, AK, CJ, GAW, BG, LB, and JN provided comments and inputs to revise the manuscript.

Competing interests
None declared.

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Data sharing statement
Data are available on reasonable request.

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Ethics approval
This study involves human participants. Ethics approval was obtained from the Rheinisch-Westfälische Technische Hochschule Aachen Human Ethics Research Committee (351/20).

Patient consent for publication
Not required.

REFERENCES

1 Nussbaumer-Streit B, Mayr V, Dobrescu AI, et al. Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. *Cochrane Database Syst Rev* 2020;4:CD013574.
2 Webster RK, Brooks SK, Smith LE, et al. How to improve adherence with quarantine: rapid review of the evidence. *Public Health* 2020;182:163–69.
3 Jarvis CI, van Zandvoort K, Gimma A, et al. Quantifying the impact of physical distance measures on the transmission of COVID-19 in the UK. *BMC Med* 2020;18(1):124. doi:10.1186/s12916-020-01597-8 [published Online First: 7 May 2020].
4 Al-Hanawi MK, Angawi K, Alshareef N, et al. Knowledge, Attitude and Practice Toward COVID-19 Among the Public in the Kingdom of Saudi Arabia: A Cross-Sectional Study. *Front Public Health* 2020;8:217. doi:10.3389/fpubh.2020.00217 [published Online First: 27 May 2020].
5 Hills S, Eraso Y. Factors associated with non-adherence to social distancing rules during the COVID-19 pandemic: a logistic regression analysis. *BMC Public Health*

2021;21(1):352. doi:10.1186/s12889-021-10379-7 [published Online First: 13 February 2021].

6 Clark C, Davila A, Regis M, et al. Predictors of COVID-19 voluntary compliance behaviors: An international investigation. *Glob Transit* 2020:76–82. doi:10.1016/j.glt.2020.06.003 [published Online First: 26 June 2020].

7 Crane MA, Shermock KM, Omer SB, et al. Change in Reported Adherence to Nonpharmaceutical Interventions During the COVID-19 Pandemic, April-November 2020. *JAMA* 2021;325(9):883–85.

8 Lüdecke D, Knesebeck O von dem. Protective Behavior in Course of the COVID-19 Outbreak-Survey Results From Germany. *Front Public Health* 2020;8:572561. doi:10.3389/fpubh.2020.572561 [published Online First: 24 September 2020].

9 Szwarcwald CL, Souza Júnior PRB de, Malta DC, et al. Adesão às medidas de restrição de contato físico e disseminação da COVID-19 no Brasil. *Epidemiol Serv Saude* 2020;29(5):e2020432.

10 Madewell ZJ, Yang Y, Longini IM, et al. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. *JAMA Netw Open* 2020;3(12):e2031756. doi:10.1001/jamanetworkopen.2020.31756 [published Online First: 1 December 2020].

11 Carlsen EØ, Caspersen IH, Trogstad L, et al. Public adherence to governmental recommendations regarding quarantine and testing for COVID-19 in two Norwegian cohorts. medRxiv 20248405. [Preprint]. December 20, 2020 [cited 2022 March 23] https://doi.org/10.1101/2020.12.18.20248405

12 Smith LE, Potts HWW, Amlôt R, et al. Adherence to the test, trace, and isolate system in the UK: results from 37 nationally representative surveys. *BMJ* 2021;372:n608. doi:10.1136/bmj.n608 [published Online First: 31 March 2021].

13 Verberk JDM, Anthierens SA, Tonkin-Crine S, et al. Experiences and needs of persons living with a household member infected with SARS-CoV-2: A mixed method study. *PLoS ONE* 2021;16(3):e0249391. doi:10.1371/journal.pone.0249391 [published Online First: 31 March 2021].

14 Hsu L, Grüne B, Buess M, et al. COVID-19 Breakthrough Infections and Transmission Risk: Real-World Data Analyses from Germany's Largest Public Health Department (Cologne). *Vaccines (Basel)* 2021;9(11). doi:10.3390/vaccines9111267 [published Online First: 2 November 2021].

15 Andrews N, Stowe J, Kirsebom F, et al. Covid-19 Vaccine Effectiveness against the Omicron (B.1.1.529) Variant. *N Engl J Med* 2022. doi:10.1056/NEJMoa2119451 [published Online First: 2 March 2022].

16 Joisten C, Kossow A, Book J, et al. How to manage quarantine-adherence, psychosocial consequences, coping strategies and lifestyle of patients with COVID-19 and their confirmed contacts: study protocol of the CoCo-Fakt surveillance study, Cologne, Germany. *BMJ Open* 2021;11(4):e048001. doi:10.1136/bmjopen-2020-048001 [published Online First: 13 April 2021].

17 Betsch C, Wieler L, Bosnjak M, et al. Germany COVID-19 Snapshot MOnitoring (COSMO Germany): Monitoring knowledge risk perceptions preventive behaviours and public trust in the current coronavirus outbreak in Germany 2020. Available at: https://psycharchives.org/en/item/e5acdc65-77e9-4fd4-9cd2-bf6aa2dd5eba Accessed March 15, 2022.

For peer review only

18 Neuhann F, Buess M, Wolff A, et al. Entwicklung einer Software zur Unterstützung der Prozesse im Gesundheitsamt der Stadt Köln in der SARS-CoV-2-Pandemie, Digitales Kontaktmanagement (DiKoMa). *Epidemiologisches Bulletin* 2020;2020(23):3–11.

19 Lange C, Jentsch F, Allen J, et al. Data Resource Profile: German Health Update (GEDA)--the health interview survey for adults in Germany. *Int J Epidemiol* 2015;44(2):442–50. doi:10.1093/ije/dyv067 [published Online First: 15 May 2015].

20 World Health Organization. Home care for patients with suspected or confirmed COVID-19 and management of their contacts 2020. Available at: https://www.who.int/publications/i/item/home-care-for-patients-with-suspected-novel-coronavirus-(ncov)-infection-presenting-with-mild-symptoms-and-management-of-contacts Accessed March 15, 2022.

21 European Centre for Disease Prevention and Control. Infection prevention and control in the household management of people with suspected or confirmed coronavirus disease (COVID-19) 2020. Available at: https://www.ecdc.europa.eu/sites/default/files/documents/Home-care-of-COVID-19-patients-2020-03-31.pdf Accessed March 15, 2022.

22 Robert Koch-Institut. Häusliche Isolierung bei bestätigter COVID-19-Erkrankung 2021. Available at: https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Flyer_Patienten.pdf?__blob=publicationFile Accessed March 15, 2022.

23 Kaduszkiewicz H, Kochen M, Pömsl J. Handlungsempfehlung Häusliche Isolierung von CoViD-19-Fällen mit leichtem Krankheitsbild und Verdachtsfällen 2020. Available at: https://www.degam.de/files/Inhalte/Leitlinien-Inhalte/Dokumente/DEGAM-S1-Handlungsempfehlung/053-054%20SARS-CoV-2%20und%20Covid-19/Publikationsdokumente%20Archiv/053-054_Empfehlungen%20Haeusliche_Isolierung.pdf Accessed March 15, 2022.

24 Wang CC, Prather KA, Sznitman J, et al. Airborne transmission of respiratory viruses. *Science* 2021;373(6558).

25 German Federal Ministry of Health, Public Relations Division. Together against corona: How to protect ourselves against the coronavirus 2021. Available at: https://assets.zusammengegencorona.de/eaae45wp4t29/59kagmqA8AWs87Jo2VgpTf/f826234fc4d8d58a891c9d159d2627aa/BMG_Infoflyer_kurz_Corona_English.pdf Accessed March 15, 2022.

26 Rosenstock IM. The Health Belief Model and Preventive Health Behavior. *Health Education Monographs* 1974;2(4):354–86.

27 Al Zabadi H, Yaseen N, Alhroub T, et al. Assessment of Quarantine Understanding and Adherence to Lockdown Measures During the COVID-19 Pandemic in Palestine: Community Experience and Evidence for Action. *Front Public Health* 2021;9:570242. doi:10.3389/fpubh.2021.570242 [published Online First: 2 March 2021].

28 Park CL, Russell BS, Fendrich M, et al. Americans' COVID-19 Stress, Coping, and Adherence to CDC Guidelines. *J Gen Intern Med* 2020.

29 Blom AG, Cornesse C, Friedel S, et al. Mannheimer Corona-Studie: GESIS Data Archive 2021.

30 Al-Sabbagh MQ, Al-Ani A, Mafrachi B, et al. Predictors of adherence with home quarantine during COVID-19 crisis: the case of health belief model. *Psychol Health Med* 2021:1–13. doi:10.1080/13548506.2021.1871770 [published Online First: 11 January 2021].

For peer review only

31 Stadt Köln - Amt für Stadtentwicklung und Statistik. Kölner Zahlenspiegel 2020 2020. Available at: https://www.stadt-koeln.de/mediaasset/content/pdf15/statistik-standardinformationen/k%C3%B6lner_zahlenspiegel_2020_deutsch.pdf Accessed March 15, 2022.
32 Telenti A, Arvin A, Corey L, et al. After the pandemic: perspectives on the future trajectory of COVID-19. *Nature* 2021;596(7873):495–504. doi:10.1038/s41586-021-03792-w [published Online First: 8 July 2021].
33 Loss J, Boklage E, Jordan S, et al. Risikokommunikation bei der Eindämmung der COVID-19-Pandemie: Herausforderungen und Erfolg versprechende Ansätze. *Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz* 2021;64(3):294–303. doi:10.1007/s00103-021-03283-3 [published Online First: 9 February 2021].

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FOOTNOTES

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Legends:

Figure 1: Participants-Flow Chart

Figure 2: Relative distribution of implementation (left) and difficulty (right) of selected recommendations in domestic isolation and quarantine; separated for infected persons (IP) and their contacts (CP)

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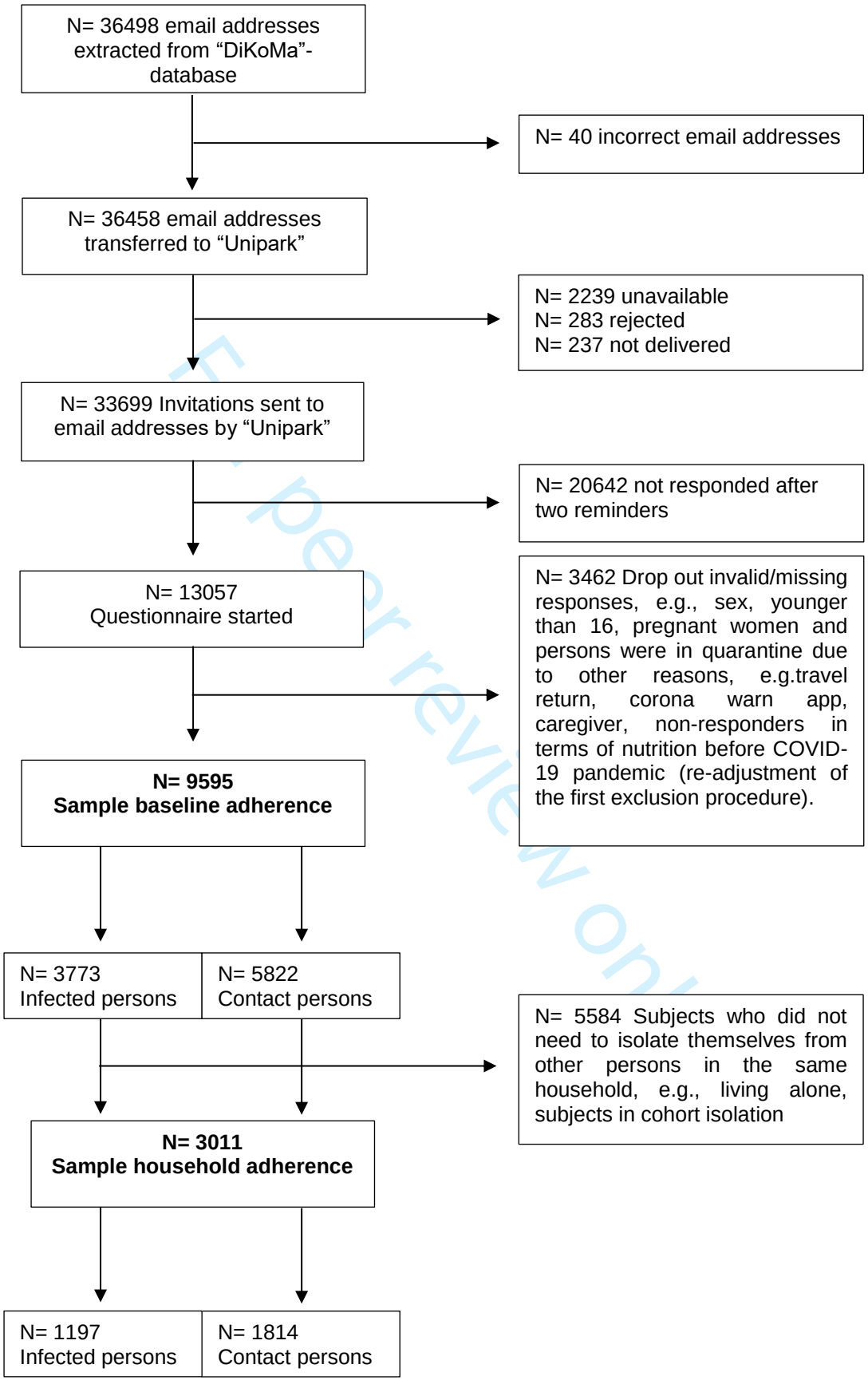

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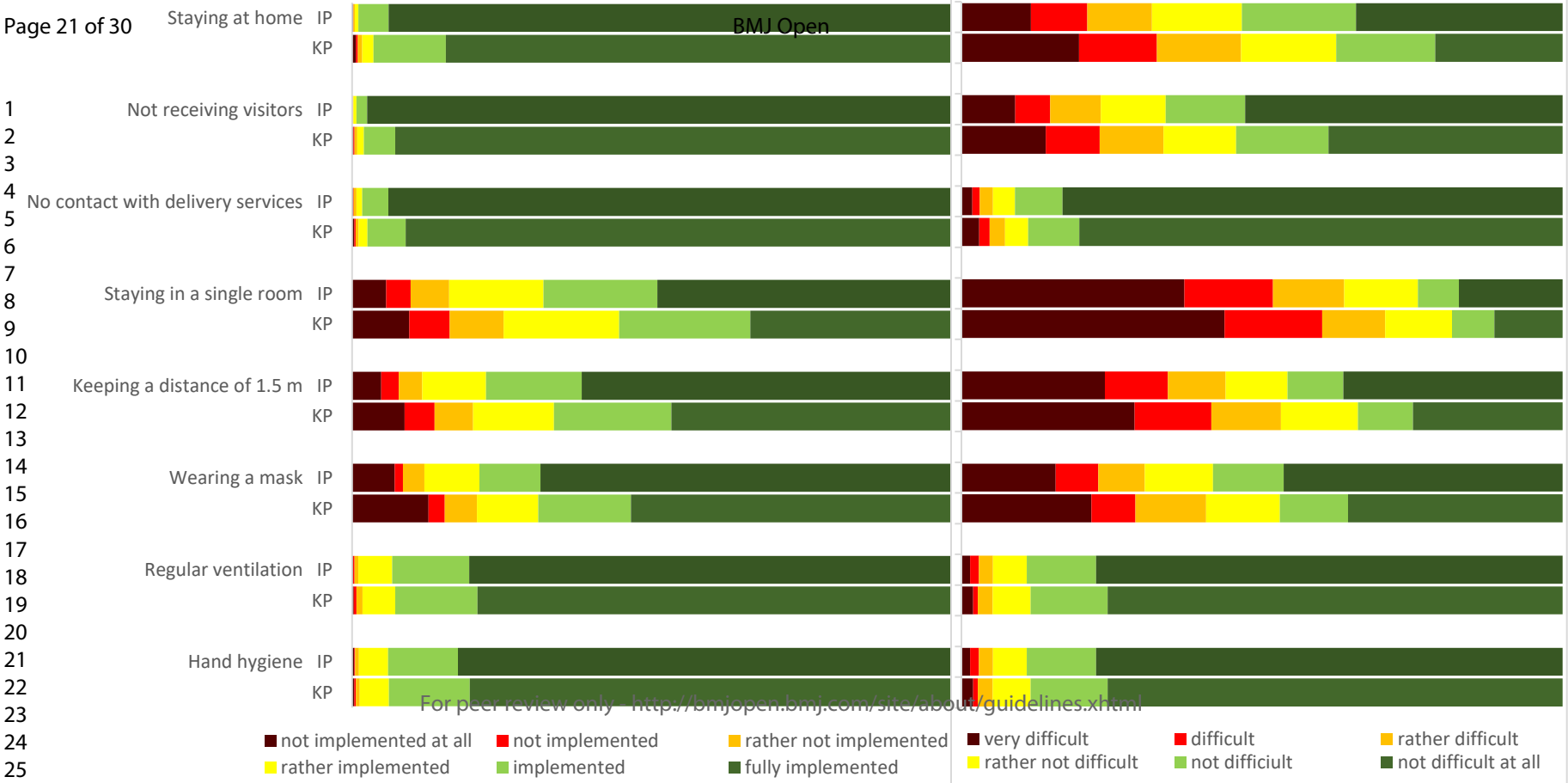

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SUPPLEMENTARY MATERIAL

Adherence to stay-at-home orders: awareness, implementation and difficulties of the officially ordered quarantine measures in the context of the SARS-CoV2 pandemic in Cologne - a cross-sectional cohort study

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*Table S1: Awareness of isolation/quarantine recommendations. *(yes=1; no=2); CBR=Community based recommendation; HBR= Household based recommendation*

Recommendation			Infected persons			Contact persons			p-value
			N	Mean value *	SD	N	Mean value *	SD	
1	Do not leave your home.	CBR	3773	1.01	0.11	5822	1.02	0.14	.003
2	Do not receive visitors.	CBR	3773	1.01	0.10	5822	1.02	0.12	.009
3	Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.	CBR	3773	1.07	0.25	5822	1.12	0.32	<.001
4	Stay apart from other household members in a single room.	HBR	1184	1.06	0.24	1801	1.11	0.32	<.001
5	Sleep separately from other household members in a single room.	HBR	1182	1.12	0.33	1792	1.20	0.40	<.001
6	Have contact with other household members only when you need their help.	HBR	1173	1.19	0.39	1783	1.29	0.45	<.001
7	Keep at least a 1.5m distance when in contact with other household members.	HBR	1154	1.11	0.32	1772	1.16	0.37	<.001
8	Wear a mouth-nose mask when in contact with other household members.	HBR	1152	1.26	0.44	1767	1.37	0.48	<.001
9	Take your meals in a different room from other household members.	HBR	1145	1.20	0.40	1750	1.29	0.46	<.001
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	HBR	1144	1.19	0.39	1741	1.28	0.45	<.001
11	Use only one toilet. The rest of the household members should not use this toilet.	HBR	604	1.20	0.40	940	1.32	0.47	<.001
12	The bathroom you use should be cleaned at least once a day.	HBR	1142	1.47	0.50	1742	1.57	0.50	<.001
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	HBR	1133	1.38	0.49	1729	1.48	0.50	<.001
14	Air all rooms regularly.	HBR	1130	1.08	0.27	1729	1.10	0.30	.160
15	Sneeze into the crook of your elbow or a disposable handkerchief.	HBR	1124	1.03	0.16	1723	1.02	0.14	.327
16	Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.	HBR	1117	1.05	0.23	1715	1.05	0.21	.357
17	Collect tissues, gloves and other rubbish in a lidded bin in your room.	HBR	1112	1.56	0.50	1707	1.61	0.49	.018
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.	HBR	1107	1.35	0.48	1685	1.44	0.50	<.001
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.	HBR	1107	1.63	0.48	1693	1.69	0.46	<.001

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*Table S2: Implementation of isolation/quarantine recommendations. **(not implemented at all=1; fully implemented=2); CBR=Community based recommendation; HBR= Household based recommendation*

Recommendation			Infected persons			Contact persons			p-value
			N	Mean value **	SD	N	Mean value **	SD	
1	Do not leave your home.	CBR	3710	5.92	0.37	5656	5.78	0.65	<.001
2	Do not receive visitors.	CBR	3724	5.96	0.26	5703	5.89	0.46	<.001
3	Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.	CBR	3497	5.91	0.42	5090	5.86	0.52	<.001
4	Stay apart from other household members in a single room.	HBR	1105	4.85	1.47	1590	4.38	1.62	<.001
5	Sleep separately from other household members in a single room.	HBR	1031	5.49	1.33	1418	5.00	1.82	<.001
6	Have contact with other household members only when you need their help.	HBR	936	5.29	1.33	1261	4.95	1.55	<.001
7	Keep at least a 1.5m distance when in contact with other household members.	HBR	1010	5.15	1.38	1474	4.70	1.62	<.001
8	Wear a mouth-nose mask when in contact with other household members.	HBR	846	5.20	1.47	1104	4.73	1.75	<.001
9	Take your meals in a different room from other household members.	HBR	908	5.12	1.53	1230	4.56	1.86	<.001
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	HBR	922	5.06	1.47	1239	4.55	1.77	<.001
11	Use only one toilet. The rest of the household members should not use this toilet.	HBR	482	5.52	1.20	633	5.37	1.37	.057
12	The bathroom you use should be cleaned at least once a day.	HBR	601	5.30	1.22	741	5.18	1.34	.065
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	HBR	686	5.13	1.30	902	5.00	1.37	.071
14	Air all rooms regularly.	HBR	1028	5.72	0.65	1556	5.69	0.70	.275
15	Sneeze into the crook of your elbow or a disposable handkerchief.	HBR	1080	5.91	0.40	1681	5.88	0.47	.13
16	Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.	HBR	1048	5.74	0.65	1630	5.72	0.67	.363
17	Collect tissues, gloves and other rubbish in a lidded bin in your room.	HBR	485	5.64	0.95	667	5.59	1.02	.455
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.	HBR	715	5.66	0.83	942	5.61	0.86	.230
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.	HBR	408	5.26	1.39	515	5.11	1.49	.118

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*Table S3: Difficulty of isolation/quarantine recommendations. ***(not difficult at all=1; very difficult=2); CBR=Community based recommendation; HBR= Household based recommendation*

Recommendation			Infected persons			Contact persons			p-value
			N	Mean value ***	SD	N	Mean value ***	SD	
1	Do not leave your home.	CBR	3722	4.24	1.74	5686	3.60	1.81	<.001
2	Do not receive visitors.	CBR	3729	4.72	1.69	5713	4.23	1.84	<.001
3	Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.	CBR	3499	5.64	0.97	5089	5.54	1.13	<.001
4	Stay apart from other household members in a single room.	HBR	1102	2.89	1.89	1583	2.55	1.77	<.001
5	Sleep separately from other household members in a single room.	HBR	1026	4.24	2.09	1409	3.91	2.17	<.001
6	Have contact with other household members only when you need their help.	HBR	938	4.02	2.00	1256	3.70	2.02	<.001
7	Keep at least a 1.5m distance when in contact with other household members.	HBR	1010	3.80	2.04	1467	3.35	1.97	<.001
8	Wear a mouth-nose mask when in contact with other household members.	HBR	843	4.36	1.90	1091	3.91	1.97	<.001
9	Take your meals in a different room from other household members.	HBR	904	3.90	1.99	1224	3.47	2.00	<.001
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	HBR	919	3.93	1.96	1233	3.49	1.99	<.001
11	Use only one toilet. The rest of the household members should not use this toilet.	HBR	481	5.31	1.46	627	5.20	1.50	.259
12	The bathroom you use should be cleaned at least once a day.	HBR	596	4.85	1.61	738	4.86	1.59	.905
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	HBR	682	4.71	1.63	899	4.64	1.61	.353
14	Air all rooms regularly.	HBR	1030	5.57	0.98	1553	5.54	1.00	.483
15	Sneeze into the crook of your elbow or a disposable handkerchief.	HBR	1079	5.81	0.73	1679	5.80	0.75	.824
16	Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.	HBR	1047	5.59	0.94	1631	5.64	0.86	.219
17	Collect tissues, gloves and other rubbish in a lidded bin in your room.	HBR	480	5.56	1.01	664	5.54	1.07	.675
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.	HBR	716	5.56	1.00	940	5.54	0.97	.676
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.	HBR	401	5.12	1.52	512	4.99	1.55	.177

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*Table S4: Views on Covid-19 in relation to quarantine. Hypothetical factors influencing the use of preventive health measures according to the Health Belief Model with statements adapted to the Covid-19 pandemic and isolation/quarantine. Sample size, mean value of agreement and standard deviation (SD) are shown separately for index persons and contact persons. P-value is given for the t-test for independent samples. * (1≙ I do not agree at all; 6 ≙ I fully agree); ** (1 ≙ yes; 2≙no)*

Influencing factor according to the Health Belief Model	Statement or question adapted to the Covid-19 pandemic and isolation/quarantine	Infected persons			Contact persons			P-Value
		N	Mean value	SD	N	Mean value	SD	
Health Knowledge	I have been given clear information about the reason for the isolation/quarantine.	3742	5.3*	1.3	5786	4.8*	1.7	<.001
	It was explained to me in an understandable way how to behave in isolation/quarantine.	3746	5.1*	1.4	5774	4.7*	1.7	<.001
Peer group pressure	People in my professional and social environment have expected me to implement the quarantine measures.	3706	5.5*	1.2	5732	5.3*	1.3	<.001
Threat Perceptions	I think the coronavirus is dangerous.	3750	5.4*	1.1	5784	5.5*	0.9	<.001
Perceived Benefits	When I isolate/quarantine myself, I am protecting myself.	3685	3.7*	2.1	5730	3.9*	2.0	.008
	When I isolate/ quarantine myself, I am protecting other members of my household.	3712	4.6*	1.8	5725	4.4*	1.9	<.001
	When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus.	3748	5.8*	0.7	5790	5.8*	0.7	<.001
Perceived Barriers	I experienced difficulties in obtaining everyday necessities during isolation/quarantine	3748	2.4*	1.7	5781	2.3*	1.7	.061
	I suffered financial losses due to the isolation/quarantine (yes/no)	3239	1.8**	0.4	4956	1.8**	0.4	.271
Expected Result	I think the isolation/ quarantine measures are too strict.	3724	2.2*	1.7	5757	2.5*	1.7	<.001
	I think the quarantine measures are too lax.	3696	2.4*	1.7	5697	2.4*	1.6	.200

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Table S5: Distribution of the baseline adherence score

Baseline adherence score (%)	Infected persons		Contact persons		Total	
	N	%	N	%	N	%
0	17	0.5	51	0.9	68	0.7
>0-20	3	0.1	10	0.2	13	0.1
>20-40	24	0.6	89	1.5	113	1.2
>40-60	45	1.2	214	3.7	259	2.7
>60-80	295	7.8	688	11.8	983	10.2
>80-<100	371	9.8	993	17.1	1364	14.2
100	3018	80.0	3777	64.9	6795	70.8

Table S6: Distribution of the household adherence score

Household adherence score (%)	Infected persons		Contact persons		Total	
	N	%	N	%	N	%
0	25	2.1	42	2.3	67	2.2
>0-20	52	4.3	105	5.8	157	5.2
>20-40	119	9.9	253	13.9	372	12.4
>40-60	191	16.0	373	20.6	564	18.7
>60-80	259	21.6	419	23.1	678	22.5
>80-<100	278	23.2	348	19.2	626	20.8
100	273	22.8	274	15.1	547	18.2

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*Table S7: Factors influencing the baseline and household adherence score. Baseline models of linear backward regression analyses *(disagree=1; agree=2)*

Baseline models	Non-Standardised Coefficients		Standardised Coefficients		95% Confidence Interval	
	Regression Coefficient (B)	Std. Error	Beta	Sig.	Lower Limit	Upper Limit
Baseline adherence score						
Infected persons (1) vs. Contact persons (2)	-0.030	0.003	-0.102	<.001	-0.037	-0.024
Age (years)	0.001	0.000	0.055	<.001	<0.001	0.001
Gender (female=1; male=2)	-0.001	0.003	-0.002	.860	-0.007	0.006
Migration background (no= 1; yes=2)	0.012	0.008	0.017	.133	-0.004	0.027
Socioeconomic status (SES) (high=1; middle and low=2)	-0.007	0.004	-0.018	.116	-0.016	0.002
Comorbidity (yes=1; no=2)	0.002	0.004	0.004	.708	-0.007	0.010
Married/ living in a Relationship (no=1; yes=2)	-0.001	0.004	-0.003	.791	-0.009	0.007
Having Children (yes=1; no=2)	-0.010	0.004	-0.033	.023	-0.018	-0.001
Access to balcony or garden (yes=0; no=1)	-0.002	0.005	-0.006	.640	-0.012	0.007
I think the coronavirus is dangerous. *	0.011	0.008	0.017	.175	-0.005	0.027
I have been given clear information about the reason for the isolation/quarantine. *	0.007	0.006	0.017	.244	-0.005	0.018
It was explained to me in an understandable way how to behave in quarantine. *	0.047	0.006	0.125	<.001	0.036	0.058
I think the isolation/ quarantine measures are too strict. *	-0.016	0.004	-0.048	<.001	-0.024	-0.008
I think the isolation/ quarantine measures are too lax. *	-0.012	0.004	-0.037	.002	-0.020	-0.005
When I isolate/quarantine myself, I am protecting myself. *	0.004	0.004	0.013	.268	-0.003	0.011
When I isolate/ quarantine myself, I am protecting other members of my household. *	0.012	0.004	0.038	.002	0.005	0.020
When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus.*	0.044	0.013	0.041	.001	0.019	0.070
People in my professional and social environment have expected me to implement the quarantine measures. *	0.037	0.006	0.070	<.001	0.025	0.049
I experienced difficulties in obtaining everyday necessities during isolation/quarantine *	-0.015	0.004	-0.044	<.001	-0.023	-0.007
I suffered financial losses due to the isolation/quarantine (yes=1; no=2)	-0.005	0.004	-0.012	.294	-0.013	0.004
Household adherence score						
Infected persons (1) vs. Contact persons (2)	-0.052	0.010	-0.102	<.001	-0.072	-0.032
Age (years)	0.002	0.001	0.104	<.001	0.001	0.003
Sex (female=1; male=2)	0.023	0.010	0.046	.023	0.003	0.043
Migration background (no= 1; yes=2)	0.067	0.022	0.060	.003	0.023	0.110

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Socioeconomic status (SES) (high=1; middle and low=2)	-0.028	0.012	-0.045	.024	-0.053	-0.004
Comorbidity (yes=1; no=2)	-0.006	0.012	-0.010	.608	-0.030	0.018
Married/ living in a Relationship (no=1; yes=2)	0.064	0.014	0.101	<.001	0.036	0.091
Having Children (yes=1; no=2)	-0.029	0.013	-0.058	.029	-0.054	-0.003
Access to balcony or garden (yes=0; no=1)	-0.015	0.017	-0.017	.391	-0.048	0.019
I think the coronavirus is dangerous. *	0.055	0.023	0.049	.019	0.009	0.101
I have been given clear information about the reason for the isolation/quarantine. *	0.040	0.017	0.057	.019	0.007	0.074
It was explained to me in an understandable way how to behave in quarantine. *	0.032	0.016	0.048	.047	0.000	0.064
I think the isolation/ quarantine measures are too strict. *	-0.015	0.012	-0.026	.201	-0.038	0.008
I think the isolation/ quarantine measures are too lax. *	-0.012	0.011	-0.022	.276	-0.035	0.010
When I isolate/quarantine myself, I am protecting myself. *	0.008	0.010	0.015	.455	-0.012	0.028
When I isolate/ quarantine myself, I am protecting other members of my household. *	0.142	0.013	0.236	<.001	0.117	0.167
When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus.*	0.069	0.042	0.034	.099	-0.013	0.150
People in my professional and social environment have expected me to implement the quarantine measures. *	0.007	0.019	0.007	.729	-0.031	0.045
I experienced difficulties in obtaining everyday necessities during isolation/quarantine *	-0.004	0.012	-0.006	.766	-0.028	0.021
I suffered financial losses due to the isolation/quarantine (yes=1; no=2)	-0.025	0.013	-0.040	.049	-0.049	<0.001

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-7*
Bias	9	Describe any efforts to address potential sources of bias	4-7
Study size	10	Explain how the study size was arrived at	5 (Fig. 1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	7
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5 (Fig.1)
		(b) Give reasons for non-participation at each stage	5 (Fig.1)
		(c) Consider use of a flow diagram	Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8 (Tab. 2)
		(b) Indicate number of participants with missing data for each variable of interest	8, Fig. 1, Tab. 2
Outcome data	15*	Report numbers of outcome events or summary measures	8-12

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-12
		(*b*) Report category boundaries when continuous variables were categorized	not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	2-3, 12-13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	17

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Adherence to stay-at-home orders: Awareness, implementation and difficulties of officially ordered quarantine measures in the context of the COVID-19 pandemic in Cologne – A retrospective cohort study

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Adherence to stay-at-home orders: Awareness, implementation and difficulties of officially ordered quarantine measures in the context of the COVID-19 pandemic in Cologne – A retrospective cohort study

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ABSTRACT

Objectives:
To estimate the awareness, implementation and difficulty of behavioural recommendations and their correlates in officially ordered domestic isolation and quarantine during the COVID-19 pandemic.

Design:
Online retrospective cohort survey conducted from 12 December 2020 to 6 January 2021 as part of the Cologne-Corona Counselling and Support for Index and Contact Persons During the Quarantine Period study (CoCo-Fakt).

Setting:
Administrative area of the city of Cologne, Germany.

Participants:
3011 infected persons and 5822 contacts over 16 years of age who were in officially ordered domestic isolation or quarantine between 28 February 2020 and 09 December 2020. Of these, 60.4% were women.

Outcome measures:
Self-developed scores were calculated, based on responses about awareness and implementation of 19 behavioural recommendations, to determine community- and household-based adherence. Linear regression analyses were conducted to determine factors influencing adherence.

Results:
The average adherence to all recommendations, including staying in a single room, keeping distance and wearing a mask, was 13.8±2.4 out of 15 points for community-based recommendations (CBRs) and 17.2±6.8 out of 25 points for household-based recommendations (HBRs). Infected persons were significantly more adherent to CBRs (14.3±2.0 vs. 13.7±2.6 points; p<.001) and HBRs (18.2±6.7 vs. 16.5±6.8 points; p<.001) than were contact persons. Among other factors, both status as an infected person and being informed about the measures positively influenced participants' adherence. The linear regression analysis explained 6.6% and 14.4% (corr. R^2) of the adherence to HBRs and CBRs.

Conclusion
Not all persons under official quarantine were aware of the relevant behavioural recommendations. This was especially true in cases where instructions were given for measures to be taken in one's own household. Due to the high transmission rates within households, HBRs should be communicated with particular emphasis.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- A large, homogenous cohort of participants in officially ordered isolation and quarantine, a subgroup for which studies on adherence are lacking.
- Detailed consideration of the various recommendations for domestic isolation and quarantine, taking motivation into account.
- Limitation to the catchment area of the Cologne Health Department, Germany.

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- Selection bias due to the online format of the survey.
- Non-compliance with officially ordered isolation and quarantine measures is a punishable offence in Germany. Even though the anonymity of participants was explicitly mentioned in our survey, it cannot be ruled out that this led to desired, less honest answers.

INTRODUCTION

Alongside vaccination, public health interventions such as restrictions on public life, social distancing and, in particular, the isolation of people infected with COVID-19 (infected persons [IPs]) and the quarantine of their close contacts (contact persons [CPs]) continue to constitute a central pillar of COVID-19 control in many countries.[1] Therefore, there have been severe penalties if officially ordered quarantine and isolation measures are not followed. In Germany at the time of the survey, punishment betrayed an income-related fine of over 20,000€ or a prison sentence of up to 5 years, which was relatively high by international comparison. In other countries such as Japan or Sweden, no penalties were threatened in cases of disregarding isolation and quarantine recommendations.[2]

Analyses of adherence to social distancing measures during the COVID-19 pandemic, however, have yielded findings ranging from 87% adherence[3] to 92.8% non-adherence[4] due to different questionnaire items and assessment criteria. Despite this heterogeneity, it has generally been shown that women, older people, those with higher levels of education or socioeconomic status (SES) and people with no dependent children were more likely to implement the interventions than were men, younger people or those with lower levels of education or SES.[3–8] In addition to financial–existential problems such as lost income or social obligations to others and cultural–religious issues such as restrictions on religious practice, psychological factors such as depression and anxiety also seem to have had a negative influence on adherence to COVID-19 protection measures (Solomou et al.[9], Wang et al.[10], Al-Sabbagh et al.[11]). Conversely, the COVID-19 pandemic and its associated countermeasures have had adverse effects on mental well-being, particularly on rates of depression and anxiety in the population (Kunzler et al.[12] and Rajkumar[13]).

The aforementioned studies mainly address general social distancing measures and self-isolation; adherence to officially ordered isolation and quarantine has been hardly investigated before now. A Norwegian cohort study identified almost 1900 people with positive COVID-19 tests from August to October 2020. Among them, only 79% of men and 91% of women adhered to isolation.[14] In a UK cohort study that included 1213 people with COVID-19-suspected symptoms, only 42.5% reported not leaving the house in the 10 days after symptom onset. Verberk et al. also examined households' levels of implementing recommendations in a small study of 34 households, each with an index case. While in most households, staying in the same room with the IP was avoided and ventilation increased, wearing masks in the household was often not considered useful and was rarely implemented.[15]

Although COVID-19 vaccination significantly reduces infection rates and the infectivity of those affected, isolation and quarantine measures continue to be highly valued responses to the pandemic in the context of emerging variants of concern and reduced vaccine efficacy against these variants.[16, 17] It is therefore essential to understand the general level of awareness and implementation of various measures and of possible factors influencing

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awareness and implementation, especially among persons at risk of transmission, such as IPs, or at risk of disease, such as CPs.

Therefore, within the Cologne-Corona Counselling and Support for Index and Contact Persons During the Quarantine Period (CoCo-Fakt) cohort study [18], IPs and CPs in the area of responsibility of the Cologne Health Department, the largest health department in Germany [17], were retrospectively and anonymously surveyed regarding their adherence to quarantine measures following an officially ordered domestic quarantine. Based on Tong et al.[19], the study recorded components of the Health Belief Model, in addition to socio-demographic factors such as age, gender, living or relationship situation and level of education. This model is intended to capture people's intentions to take or refrain from taking health measures.[20] These include the main constructs Perceived Benefits, Perceived Barriers, Expected Results, Psychological Characteristics/Peer Group Pressure, and Cues to Action/Health Knowledge.[21] The additional analysis of these variables in the context of quarantine adherence should help to develop effective measures.

METHODS

Study design

Beginning in February 2020, trained staff from the Cologne Health Authority contacted IPs and CPs by telephone and questioned them in a standardised interview regarding their symptoms, possible routes of infection, chronic diseases, risk factors and residential and family situations.[17] These individuals had been quarantined based on the legal regulations for combating infectious diseases according to the Infectious Diseases Protection Act (in German, *Infektionsschutzgesetz*, or IfSG), with the usual length of quarantine for IPs being 14 days after symptom onset or a positive test result. The quarantine period for CPs was 10–14 days at the time of this survey, depending on the time of last contact. Until October 2020, this period could be extended, lasting several weeks for families that could not be physically separated. All data were recorded using the Cologne Health Authority's specially programmed software, the digital contact management system DiKoMa.[22]

The CoCo-Fakt study integrated all IPs and their relevant CPs, who had been quarantined by Cologne's local health authorities since the beginning of the COVID-19 pandemic in February 2020. Therefore, from 28 February (the date of the first COVID-19 case in Cologne) to 9 December 2020, all persons who were at least 16 years old, registered in DiKoMa with a positive SARS-CoV-2 test (by quantitative real-time polymerase chain reaction) and whose written informed consent was obtained were integrated into this analysis along with their relevant CPs.

The demographic factors of this survey were based on a modified version of the COVID-19 Snapshot Monitoring questionnaire from the University of Erfurt (COSMO).[23] In addition, items on awareness and implementation of the behavioural recommendations were derived from the official recommendations provided by the World Health Organization (WHO), the European Centre for Disease Prevention and Control, the Robert Koch Institute (RKI) and the German Society for General and Family Medicine.[24–27]

To prevent participants from providing untruthful information in the questionnaire, for fear of prosecution upon admitting incompliant behaviour, participants were explicitly informed

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in the written clarification that the answers would be evaluated anonymously and could not be assigned to specific persons.

The questionnaire was carried out by the online survey software Unipark. Ethics approval was obtained from the Rheinisch–Westfälische Technische Hochschule Aachen Human Ethics Research Committee (351/20). Responding to the questionnaire took participants approximately 30 minutes, and qualitative data were evaluated using MAXQDA software. The survey was conducted from 12.12.2020 to 6.1.2021.

The detailed study design, including the complete questionnaire, was published in advance as a study protocol.[18]

Patient and public involvement

The research questions and methods were developed based on the literature available at the time of the study's development in summer 2020. Affected persons from the researchers' personal environment were first approached and asked to respond to and assess the draft in order to optimise the survey and align it with the research questions. From this collective, 20 additional affected persons were recruited by snowball sampling, and the survey's feasibility and duration were tested during June and July 2020. The draft questionnaire was adapted and finalised based on feedback from these respondents. Since the online survey was anonymised, no individual results were given to the patients (see Joisten et al. 2021[18]).

Sampling and study population

36498 persons whose email addresses were known were identified in DiKoMa during the period under consideration. Of these, 33699 persons were sent the questionnaire, and 13057 clicked on the questionnaire. The study excluded pregnant women who were monitored and advised particularly intensively by the Cologne Health Department during the study period, persons under 16 years of age, subjects with missing or invalid essential information (sex, age, awareness of quarantine recommendations 1–3) and subjects who could not be assigned to the IP or CP groups (e.g. travel returnees) (*N*=3462). Contacts who tested positive for SARS-CoV-19 during quarantine were included in the infected group. Thus, 9595 subjects (3773 IPs and 5822 CPs) were included in the analysis of adherence to community-based recommendations (CBRs). Household-based recommendations (HBRs) were relevant only for those individuals who needed to isolate themselves from others within a household. Therefore, individuals for whom this did not apply, such as those living alone or in cohort isolation, were not included in the analysis of household-based adherence (*N*=5584). A total of 3011 subjects (1197 IPs, 1814 CPs) were included in the analysis of household-based adherence (Fig. 1).

Demographic parameters and personal living situations

Based on the COSMO survey, age, gender, migration background (yes/no), relationship status (single/partnered), chronic illnesses (yes/no), children (yes/no) and their number, lived alone (yes/no) and access to a garden or balcony (yes/no) were assessed. SES was determined based on the classifications of the German Health Update 2009.[28]

Quarantine recommendations: Awareness, implementation and difficulties

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Recommendations on behaviour in isolation and quarantine from the WHO, the European Centre for Disease Prevention and Control, the RKI and the German Society for General and Family Medicine were reviewed.[24–27] As a synopsis of all these recommendations, a list with a total of 19 relevant isolation and quarantine recommendations was compiled by the authors (Table 1).

Table 1: Behavioural recommendations in domestic quarantine and isolation. The evaluations of recommendations 1–4, 7, 8, 14 and 16 (bold), which the authors consider particularly relevant, are addressed in the paper and included in the calculation. CBR: Community-based recommendation; HBR: Household-based recommendation

No.	Recommendation	
1	**Do not leave your home.**	**CBR**
2	**Do not receive visitors.**	
3	**Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.**	
4	**Stay apart from other household members in a single room.**	**HBR**
5	Sleep separately from other household members in a single room.	
6	Have contact with other household members only when you need their help.	
7	**Keep at least a 1.5m distance when in contact with other household members.**	
8	**Wear a mouth–nose mask when in contact with other household members.**	
9	Take your meals in a different room from other household members.	
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	
11	Use only one toilet. The rest of the household members should not use this toilet.	
12	The bathroom you use should be cleaned at least once a day.	
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	
14	**Air all rooms regularly.**	
15	Sneeze into the crook of your elbow or a disposable handkerchief.	
16	**Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.**	
17	Collect tissues, gloves and other rubbish in a lidded bin in your room.	
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.	
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.	

Of these, three recommendations (do not receive visitors, stay at home and have no contact with delivery or postal workers) relate to seclusion from the public, are relevant for all persons in quarantine and were classified as CBRs. The other 16 recommendations relate to seclusion within a household and are relevant only to people who needed to isolate themselves from other household members but not to people living alone or to index people in cohort isolation; these were classified as HBRs. To identify subjects for whom HBRs were relevant, the item 'Did you have to isolate yourself from other household members during your quarantine? (yes/no)' was included in the questionnaire.

CBRs 1–3 were presented to all participants. The HBRs were presented only to subjects who indicated that they had had to isolate themselves from other household members. Recommendation 11 (use of a separate toilet) was also presented only to subjects who had previously reported living in a household with more than one toilet. For each recommendation presented, the respondents were first asked whether the respective recommendation was

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known (yes=1, no=2). If the recommendation was known, they were also asked to what extent it had been implemented and how difficult it was to implement. The survey was carried out using a 6-part interval scale with endpoints: 1 ≙ I have not implemented at all, 6 ≙ I have fully implemented, 1 ≙ I have found this very difficult and 6 ≙ I have not found this difficult at all.

Whereas at the beginning of the COVID-19 pandemic, droplet and smear infection were considered the main transmission routes, inhalation of virus-containing particles in the form of aerosols has since been identified as the most important transmission route in the further course of the pandemic.[29] The present paper considers in more detail the CBRs on staying in a single room, having regular ventilation, wearing a mouth–nose covering, keeping a distance of 1.5 m from other persons and practising hand hygiene, which are considered particularly relevant for the prevention of aerosol transmission and have been promoted in an extensive public campaign by the German Federal Ministry of Health.[30] To enable comparability of adherence in our study population with other cohorts, we recorded behaviour in isolation and quarantine for these 19 recommendations in the finest detail possible. Definitions of adherence that, for example, only consider not leaving home[31, 32] or only selected WHO recommendations[31] could thus also be recreated from our dataset. Evaluations of other recommendations can be found in the supplement (Table S1, Table S2, Table S3).

Adherence scores

Baseline adherence score

A self-developed baseline adherence score was calculated to map individual adherence and examine influencing factors. The basis for this baseline adherence score was the awareness and implementation of the particularly important CBRs 1–3.

According to the answers on the 6-part scale for the implementation of the recommendations, each respondent received points from 0 (not implemented at all) to 5 (fully implemented) for each of the three recommendations. If the respondent was unaware of the recommendation or did not provide information on implementation, 0 points were awarded. With three recommendations scored, the maximum possible score was 15, corresponding to a baseline adherence score of 100%.

Household adherence score

Following the same procedure, a self-developed household adherence score was calculated, including HBRs 4, 7, 8, 14 and 16 for all subjects who had to isolate themselves from other household members. Missing answers, as well as the answer ‘I did not implement at all’, were weighted with 0 points. With five recommendations scored, the maximum possible score was 25, corresponding to a household adherence score of 100%.

Items of the Health Belief Model

To capture in detail the factors influencing health-related behaviour under the Health Belief Model (Perceived Severity, Perceived Susceptibility, Perceived Benefits, Perceived Barriers, Expected Result, Psychological Characteristics/Peer Group Pressure and Cues to Action/Health Knowledge), we developed 11 statements or questions with hypothetical influence on adherence, with isolation and quarantine measures based on Tong et al. and Al-Sabbagh et al. rose [11, 19, 20]:

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- Perceived Severity/Perceived Susceptibility
  - 'I think the coronavirus is dangerous.'
- Perceived Benefits
  - 'When I isolate/quarantine myself, I am protecting myself.'
  - 'When I isolate/quarantine myself, I am protecting other members of my household.'
  - 'When I isolate/quarantine myself, I am protecting our society from the further spread of the coronavirus.'
- Perceived Barriers
  - 'I experienced difficulties in obtaining everyday necessities during isolation/quarantine.'
  - 'I suffered financial losses due to the isolation/quarantine.'
- Expected Result
  - 'I think the isolation/quarantine measures are too strict.'
  - 'I think the quarantine measures are too lax.'
- Psychological characteristics/Peer group pressure
  - 'People in my professional and social environment have expected me to implement the quarantine measures.'
- Cues to Action/Health Knowledge
  - 'I have been given clear information about the reason for the isolation/quarantine.'
  - 'It was explained to me in an understandable way how to behave in isolation/quarantine.

Respondents' agreement with each statement was determined using a 6-item endpoint-named interval scale (strongly disagree–strongly agree). For the question regarding financial losses due to quarantine, the answer was binary (yes/no) (Table S4).

Data analysis

Descriptive and inductive data analyses were conducted using the program SPSS 28.0 (IBM, Armonk, NY, USA). Chi-squared tests and *t*-tests were conducted to assess the differences between IPs and CPs.

Linear backward regression analyses were conducted to determine the influence of age (in years), quarantine as an IP (1) or CP (2), gender (female=1, male=2), being in a partnership (no=1, yes=2), living situation with balcony or garden (yes=0, no=1), migration background (no=1, yes=2), SES (high=1, middle and low=2), comorbidity (yes=1, no=2), presence of children in the household (yes=1, no=2), as well as the hypothetical factors influencing the baseline and household adherence scores listed previously (Table S4) (agree=1, disagree=2). Non-significant factors were excluded during stepwise regression. A *p*-value below 0.05 was considered significant.

RESULTS

Demographic parameters and personal life situation

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Among the study participants, 60.4% were women (see Table 2). The proportion of women among the contact persons was 63.0%, which was significantly higher than the proportion of women among the index persons at 56.5% (p<.001). The participants in the study were, on average, 40.9±14.2 years old. Index participants were, on average, 41.9±14.3 years old, slightly older than contacts with an average age of 40.3±14.1 years (p<.001). 5.4% of the study participants had a migration background; here, too, there was a significant difference between 7.2% of the index persons and 4.2% of the contact persons (p<.001).

*Table 2: General characteristics of participants, total and by status as infected person or contact person; * chi-squared test; **unpaired t-test*

Variable	Total *N* (%)	Infected persons *N* (%)	Contact persons *N* (%)	*p*-Value
Sample	9595 (100)	3773 (39.3)	5822 (60.7)	
Sex	9595 (100)			
Male	3797 (39.6)	1643 (43.5)	2154 (37.0)	<.001*
Female	5798 (60.4)	2130 (56.5)	3668 (63.0)	
Mean age years (SD)	40.9 (14.2)	41.9 (14.3)	40.3 (14.1)	<.001**
Age Groups (years)	9595 (100)			
16-29	2580 (26.9)	925 (24.5)	1655 (28.4)	<.001*
30-39	2260 (23.6)	853 (22.6)	1407 (24.2)	
40-49	1771 (18.5)	731 (19.4)	1040 (17.9)	
50-59	1953 (20.4)	812 (21.5)	1141 (19.6)	
60-69	789 (8.2)	339 (9.0)	450 (7.7)	
70+	242 (2.5)	113 (3.0)	129 (2.2)	
Migration background	9427 (100)			
No	8919 (94.6)	3421 (92.8)	5498 (95.8)	<.001*
Yes	508 (5.4)	265 (7.2)	243 (4.2)	
Socioeconomic status (SES)	9522 (100)			
High	7644 (80.3)	2964 (79.2)	4680 (80.9)	.007*
Middle	1790 (18.8)	731 (19.5)	1059 (18.3)	
Low	88 (0.9)	47 (1.3)	41 (0.7)	
Married/living in a relationship	9383 (100)			
No	2650 (28.2)	1012 (27.5)	1638 (28.7)	.186*
yes	6733 (71.8)	2671 (72.5)	4062 (71.3)	
Having children	9553 (100)			
No	5419 (56.7)	2070 (55.2)	3349 (57.7)	.013*
Yes	4134 (43.3)	1683 (44.8)	2451 (42.3)	
Living alone	9545 (100)			
No	6767 (70.9)	2656 (70.8)	4111 (70.9)	.905*
Yes	2778 (29.1)	1094 (29.2)	1684 (29.1)	
Access to balcony or garden	9557 (100)			
No	1443 (15.1)	530 (14.1)	913 (15.7)	.030*
Yes	8114 (84.9)	3226 (85.9)	4888 (84.3)	
Comorbidity	9264 (100)			
No	7212 (77.8)	2768 (76.2)	4444 (78.9)	.003*
Yes	2052 (22.2)	863 (23.8)	1189 (21.1)	

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Awareness of the recommendations

Results showed that 88.8% of all respondents, 92.2% of IPs and 86.6% of CPs were aware of all three CBRs (stay at home, do not receive visitors and have no contact with delivery or postal

workers). On average, 2.9±0.3 of the CBRs were known to the IPs, and 2.8±0.4 were known to the CPs (p<.001). While 98.7% of respondents were aware of the recommendation not to receive visitors, and 98.3% were aware of the recommendation not to leave home, only 90.1% were aware of the recommendation not to have contact with delivery or postal workers.
The awareness of the 16 HBRs varied more markedly. On average, 10.7±4.0 of the 16 HBRs were known to all subjects, 11.2±3.8 to the IPs and 10.3±4.0 to the CPs (p<.001). For example, only 33.2% of respondents were aware of the recommendation to wash laundry separately and at 60°C, and only 41.1% knew about the recommendation to dispose of waste in a separate waste bin. On the other hand, 97.7% and 95.1% of the respondents stated that they were aware of the recommendations on coughing and sneezing etiquette and regular hand hygiene, respectively. While the recommendations of staying in a single room, having regular ventilation and keeping a distance of 1.5m were also widely known, the recommendation to wear a mouth–nose covering inside their house or flat was less well known, especially among CPs (p<.001) (Table S1).

Implementation of the recommendations

On the 6-item endpoint-named interval scale for implementation of interventions, the three CBRs 'Do not leave your home' (IP: mean=5.9±0.4; CP: mean=5.8±0.7), 'Do not receive visitors' (IP: mean=6.0±0.3; CP: mean=5.9±0.5) and 'Avoid personal contact with postal and delivery workers' (IP: mean=5.9±0.4; CP: mean=5.9±0.5) achieved very high rates of implementation. CPs implemented the HBRs to a somewhat lesser degree (p<.001). The HBRs on regular ventilation (IP: mean=5.7±0.7; CP: mean=5.7±0.7) and hand washing (IP: mean=5.7±0.7; CP: mean=5.7±0.7) were quite well implemented, with no appreciable differences between IPs and CPs here (p=.275 and p=.363). Comparatively worse was the implementation of the HBRs on staying in a single room (IP: mean=4.9±1.5; CP: mean=4.4±1.6), keeping a distance of 1.5m (IP: mean=5.2±1.4; CP: mean=4.7±1.6) and wearing a mouth-nose mask (IP: mean=5.2±1.5; CP: mean=4.7±1.8). These recommendations, which involve distancing oneself from other household members, were implemented significantly better by the IPs than by the CPs (p<.001) (see Figure 2 and Table S2).

Baseline adherence score

The mean baseline adherence score was 13.8±2.4 out of 15 points (= 100%), equivalent to an adherence rate of 92.8%. Only 0.7% (N=68) of respondents did not observe any of the CBRs, obtaining a score of 0 points. Of the respondents, 70.8% fully implemented the included recommendations, corresponding to a baseline adherence score of 15 points. IPs achieved significantly higher adherence scores than did CPs (14.3±2.0 points vs. 13.7±2.6 points; p<.001), representing a baseline adherence of 95.3% (IPs) vs. 91.2% (CPs). In total, 64.9% of contacts and 80.0% of index persons achieved a baseline adherence score of 15 points or 100%. The detailed distribution of the baseline adherence score is shown in the supplement (Table S5).

Household adherence score

The mean household adherence score was 17.2±6.8 out of 25 points (=100%), equivalent to an adherence rate of 68.8%. Of the respondents, 2.2% (N=67) did not observe any of the HBRs, obtaining a score of 0 points, whereas 18.2% fully implemented all included recommendations, corresponding to a household adherence score of 25 points. IPs achieved a significantly higher adherence score than did CPs (18.2±6.7 points vs. 16.5±6.8 points; p<.001), representing a household adherence of 72.9% (IPs) vs. 66.0% (CPs). In total, 22.8% of

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IPs and 15.1% of CPs achieved a household adherence score of 25 points. The detailed distribution of the household adherence score is shown in the supplement (Table S6).

Difficulties of implementation

The greatest implementation difficulties were found for the recommendations requiring distancing from familiar people. The most problematic was the implementation of seclusion in a single room (IP: mean=2.9±1.9; CP: mean=2.6±1.8; 1=very difficult; 6=not difficult at all). The recommendation to wear a mouth–nose covering when in contact with other household members (IP: mean=4.4±1.9; CP: mean=3.9±2.0), to keep a distance of 1.5m (IP: mean=3.8±2.0; CP: mean=3.4±2.0), to avoid visitors (IP: mean=4.7±1.7; CP: mean=4.2±1.8) and to stay at home (IP: 4.2; CP: 3.6) were also comparatively difficult to implement. In contrast, the recommendations on regular hand washing (IP: mean=5.6±0.9; CP: mean=5.6±0.9), airing (IP: mean=5.6±1.0; CP: mean=5.5±1.0) and avoiding contact with delivery and postal workers (IP: mean=5.6±1.0; CP: mean=5.5±1.1) were easy to implement. While there were no significant differences in the perceived difficulty of implementing the recommendations on airing and hand washing between IPs and CPs (p=.483 and p=.219), the implementation of the other recommendations mentioned previously was perceived as more difficult by CPs than by IPs (p<.001) (see Figure 2 and Table S3).

Views on isolation and quarantine for COVID-19

Perceived Severity Perceived Susceptibility

On the six-point Likert scale, both IPs and CPs considered the coronavirus relatively dangerous (IP: mean=5.4±1.1; CP: mean=5.5±0.9). CPs perceived the coronavirus as significantly more dangerous than IPs (p<0.01).

Perceived Benefits

While the statement that isolation/quarantine protects oneself received comparatively low agreement among both IPs and CPs (IP: mean=3.7±2.1; CP: mean=3.9±2.0), the statement that isolation/quarantine protects other household members (IP: mean=4.6±1.8; CP: mean=4.4±1.9), as well as society, from the further spread of the coronavirus (IP: mean=5.8±0.7; CP: mean=5.8±0.7) received high or very high agreement.

Perceived Barriers

Supply shortages for everyday necessities (IP: mean=2.4±1.7; CP: mean=2.3±1.7), as well as financial losses (IP: mean=1.8±0.4; CP: mean=1.8±0.4; 1=yes, 2=no), did not seem to have existed to any great extent for participants during isolation/quarantine. There was no significant difference between IPs and CPs in this regard (p=.061 and p=.271).

Expected Results

There was also low agreement with the statements that the isolation/quarantine measures were too strict (IP: mean=2.2±1.7; CP: mean=2.5±1.7) or too lax (IP: mean=2.4±1.7; CP: mean=2.4±1.6).

Psychological Characteristics/Peer Group Pressure

Many respondents seemed to feel social pressure to implement the recommendations (IP: mean=5.5±1.2; CP: mean=5.3±1.3). IPs were significantly more likely to report having felt social pressure (p<.001).

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Health Knowledge/Cue to Action
IPs, in particular, showed a high level of agreement with the statements that they had been informed about the recommended behavioural measures of isolation/quarantine and the reason for these measures (IP: mean=5.3±1.3; CP: mean=4.8±1.7) (see Table S4).

Factors influencing adherence during isolation and quarantine

Regression analysis was used to determine factors influencing baseline adherence scores. The baseline models are shown in the supplement (Table S7). The final models are shown in Table 3. A total of 7173 subjects were included in the regression analysis of the baseline adherence score. Factors correlating with higher baseline scores included status as an IP (β=-0.102; *p*<.001), older age (β=0.055; *p*<.001), presence of children in the household (β=-0.037; *p*=.008) and agreement with the following statements: 'It was explained to me in an understandable way how to behave in quarantine' (β=0.136; *p*<.001); 'When I isolate quarantine myself, I am protecting other members of my household' (β=0. 046; *p*<.001); 'When I isolate quarantine myself, I am protecting our society from the further spread of the coronavirus' (β=0.049; *p*<.001) and 'People in my professional and social environment have expected me to implement the quarantine measures' (β=0.069; *p*<.001). Agreement with the statements that the isolation/quarantine measures were too strict (β=-0.049; *p*<.001) or too lax (β=-0.033; *p*=0.004) or that there were supply difficulties during isolation/quarantine (β=-0.042; *p*<.001) was associated with a lower baseline adherence score. The model explained 6.6% (corr. R^2) of the variance.

Factors influencing household adherence scores were analysed analogously (see supplement Table S7 and Table 3). A total of 2227 subjects were included in the regression analysis of the household adherence score. Here, factors correlating with higher household adherence scores included IP status (β=-0.103; *p*<.001), older age (β=0.108; *p*<.001), male gender (β=0.043; *p*=0.030), migration background (β=0.058; *p*=.004), lower SES (β=-0.045; *p*=0.025), living in a relationship (β=0.099; p<.001), having children in the household (β=-0.058; *p*=0.028), considering coronavirus dangerous (β=0.052; *p*=0.011) and agreement with the following statements: 'I have been given clear information about the reason for the isolation/quarantine' (β=0. 060; *p*=0.014), 'It was explained in an understandable way how to behave in isolation/quarantine' (β=0.047; p=0.051), 'When I isolate/quarantine myself, I am protecting other members of my household' (β=0.240; *p*<.001) and 'When I isolate/quarantine myself, I am protecting our society from the further spread of the coronavirus' (β=0.037; *p*=0.072). In addition, there was a positive association between financial losses due to quarantine and household adherence (β=-0.034; *p*=0.090). The model explained 14.4% (corr. R^2) of the variance.

*Table 3: Factors influencing the baseline and household adherence scores. Final models of linear backward regression analyses *(disagree=1, agree=2)*

Final Models	Non-Standardised Coefficients		Standardised Coefficients	Sig.	95% Confidence Interval	
	Regression Coefficient (B)	Std. Error	Beta		Lower Limit	Upper Limit

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Baseline adherence score						
Infected persons (1) vs. Contact persons (2)	-0.030	0.003	-0.102	<.001	-0.037	-0.024
Age (years)	0.001	<0.001	0.055	<.001	<0.001	0.001
Having children (yes=1, no=2)	-0.011	0.004	-0.037	.008	-0.019	-0.003
When I isolate/quarantine myself, I am protecting other members of my household. *	0.015	0.004	0.046	<.001	0.007	0.022
When I isolate/quarantine myself, I am protecting our society from the further spread of the coronavirus. *	0.049	0.013	0.045	<.001	0.024	0.073
I experienced difficulties in obtaining everyday necessities during isolation/quarantine *	-0.014	0.004	-0.042	<.001	-0.022	-0.006
I think the isolation/quarantine measures are too strict. *	-0.016	0.004	-0.049	<.001	-0.024	-0.009
I think the isolation/quarantine measures are too lax. *	-0.011	0.004	-0.033	.004	-0.019	-0.004
People in my professional and social environment have expected me to implement the quarantine measures. *	0.037	0.006	0.069	<.001	0.025	0.049
It was explained to me in an understandable way how to behave in quarantine. *	0.051	0.004	0.136	<.001	0.043	0.060
Household adherence score						
Infected persons (1) vs. Contact persons (2)	-0.052	0.010	-0.103	<.001	-0.072	-0.032
Age (years)	0.002	<0.001	0.108	<.001	0.001	0.003
Sex (female=1, male=2)	0.022	0.010	0.043	.030	0.002	0.042
Migration background (no= 1, yes=2)	0.064	0.022	0.058	.004	0.021	0.107
Socioeconomic status (SES) (high=1, middle and low=2)	-0.028	0.012	-0.045	.025	-0.052	-0.004
Married/living in a relationship (no=1, yes=2)	0.062	0.014	0.099	<.001	0.035	0.090
Having children (yes=1, no=2)	-0.029	0.013	-0.058	.028	-0.054	-0.003
I think the coronavirus is dangerous. *	0.059	0.023	0.052	.011	0.014	0.104
I have been given clear information about the reason for the isolation/quarantine. *	0.042	0.017	0.060	.014	0.009	0.076
It was explained to me in an understandable way how to behave in quarantine. *	0.031	0.016	0.047	.051	<0.001	0.063
When I isolate/quarantine myself, I am protecting other members of my household. *	0.145	0.012	0.240	<.001	0.121	0.169
When I isolate/quarantine myself, I am protecting our society from the further spread of the coronavirus. *	0.074	0.041	0.037	.072	-0.007	0.154
I suffered financial losses due to the isolation/quarantine (yes=1, no=2)	-0.021	0.012	-0.034	.090	-0.045	0.003

DISCUSSION

To our knowledge, this study is one of the first studies in Germany of adherence to recommendations while in official domestic isolation or quarantine during the COVID-19

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pandemic. The study showed that the measures for seclusion from the public were especially well implemented (92.8% adherence). Adherence to measures requiring distancing from other household members reached only 68.8%. The measures calling for seclusion in a single room and keeping a distance of 1.5 m from other household members were both particularly difficult to implement. By contrast, regular airing and washing of hands, as well as avoiding contact with delivery and postal workers, were easier. The lower adherence to measures of separating from other household members aligns with the results of a study by Broichhaus et al. on COVID-19 transmission routes conducted at about the same time in Cologne, according to which a large proportion of infections occurred within the same household.[32]

In the present study, men were more adherent than women, older people more adherent than younger people and IPs more adherent than CPs. The higher adherence of IPs could be due to their knowledge of acute contagiousness and a more direct benefit from the behavioural measures. However, the extent to which the higher adherence of IPs can also be attributed to symptom-related immobility remains speculative. It is evident that CPs, in particular, must be informed about the meaning and benefits of quarantine, especially if they are unvaccinated.

Al-Hanawi et al., Al-Zabadi et al. and Park et al. also found higher adherence among older people in survey studies on the implementation of social distancing measures in the general population, as did Smith et al. in a study on self-isolation at the onset of COVID-19 symptoms in a British cohort.[3, 33–35] However, in all four studies, women were more likely to implement the relevant measures. Why men performed better on HBRs in our study can only be speculated here. As the Mannheim–Corona study by Cornesse et al. suggests, women (still) feel more obliged to take on household tasks, even during quarantine.[36] Smith et al. showed lower adherence in their study among subjects with younger children in the household. However, the only criterion for adherent behaviour in their study was whether the subjects left their home.[35] Our study found a positive correlation between the presence of children in the household and greater adherence, accounting for all relevant isolation/quarantine recommendations. Subjects with children in the household implemented the HBRs significantly better than did subjects without children at home. The reason for this could be the high motivation of many parents to protect their children from infection. However, the extent to which psychosocial reasons played a role here, such as the feeling of loneliness or existential hardship, can only be speculated at this point.

These speculations are supported by the results from the Health Belief Model. Thus, the measures were predominately perceived as appropriate and not too strict. In addition to the perceived risks associated with a given disease, the assumed costs and benefits of different behaviours also influence the extent of behavioural change.[20]

Subjects who stated that they had been clearly informed about both the reason for their isolation or quarantine and the scope of the measures mandated showed greater adherence to the measures, considering ‘Health knowledge’, resp. the construct ‘Cues to Action’ in the Health Belief Model. Adherence was also positively influenced by the assessment of the measures as appropriate, as well as by the perception of social pressure in relation to their implementation, which can be attributed to the constructs Expected Results and Psychological Characteristics/ Peer Group Pressure. The construct Perceived Severity Susceptibility reflected the perception that COVID-19 is dangerous and had a further positive influence on household adherence. In cross-sectional studies of perceptions of the coronavirus and social distancing

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measures, Hills et al. and Al-Sabbagh et al. found that the perceived dangerousness of infection and identifying oneself as belonging to a risk group were both associated with higher adherence.[4, 11] Results are contradictory with regard to the construct of Perceived Barriers. While Al-Sabbagh et al. also found that a perceived financial disadvantage related to social distancing measures correlated with lower adherence, the present study associated higher expenditures or financial losses due to isolation or quarantine with higher household adherence.[11] This fact could be explained by a certain retrospective aspect of our study: those who adhered more strictly to the measures may, as a result, have had higher costs (e.g. for hygiene items or delivery services).

Strengths and limitations

A particular strength of this survey was its large, homogeneous cohort and its detailed consideration of the various recommendations, taking quarantine reason (IP or CP) motivation into account. Even though this survey was limited to the catchment area of the largest health department in Germany, the measures were largely uniform across Germany, and the approaches taken by the various health departments were comparable. This makes it quite likely that the findings can be transferred reliably to other urban regions. It must be particularly emphasised that this was a full census, taking into account the inclusion and exclusion criteria. However, mainly people with higher SES and without a migration background participated, making it difficult to transfer the findings to other target groups. Psychological, cultural–religious factors and coping strategies, which possibly also influenced adherence, were not taken into account. One further limitation, however, was the online format, which could have prevented older participants, particularly those who are less computer-literate, from participating. However, the average age of the study participants, at 40.9 years, is 13 months below the average age of the Cologne population.[37] Furthermore, when interpreting the results, it must be taken into account that citizens placed under isolation/quarantine orders were informed that non-compliance with certain measures, especially leaving one's own home, could be punished. Even though the anonymity of participation was explicitly mentioned in our survey, it cannot be ruled out that the threat of subsequent punishment led to desired and less honest answers.

Moreover, it is plausible that more of those who complied with the prescribed measures took part in the survey.

CONCLUSIONS

In summary, adherence was quite high overall, especially with regard to the general isolation/quarantine rules. However, with high infection rates in households with an index case in the past, and the comparatively lower adherence to isolation and quarantine within one household found in this study, it still seems sensible to develop more strategies for increasing adherence, particularly within households.[38] The pandemic has been ongoing for more than two years, and with the emergence of new viral variants such as Omicron and its subtypes, associated weakened vaccine effectiveness and a still-significant number of unvaccinated people, the importance of non-drug measures is clear. As Telenti et al. have indicated, responsible management of COVID-19 will continue to be relevant in the future.[39] Thus, to support staff in health offices in their care of citizens, adequate education on the benefits of quarantine measures should be implemented in the public sphere. This might also lead to increased adherence, especially within a household. The approach to successful risk communication outlined by Loss et al., which includes credible messages, acknowledgement

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of uncertainties and a balance of reassurance and alarm, combined with continuous monitoring and evaluation, could be used as a guide to preventing fatigue in future pandemics and in the ongoing development of COVID-19.[40]

Key messages and implications

- Measures of seclusion from other household members are followed more weakly overall than are measures of seclusion from the public.
- Not only uninfluenceable demographic factors such as age, gender, education level or index-person status but also the personal views and beliefs of those affected influence adherence to quarantine and isolation.
- Responsible health authorities can increase the adherence of citizens in isolation and quarantine by providing comprehensible information about the reason, benefits and scope of the recommended behavioural measures.
- Particular attention should be paid to contact persons and those who must isolate themselves from others within the same household.

Author Contributions
CJ, AK, JN and GAW conducted the study on behalf of the CoCo-Fakt study group, JB conducted the questions regarding the quarantine recommendations, CJ and JB conducted the statistical analyses, AK, CJ and JB contributed to interpreting the results, JB wrote the original draft of the manuscript, AK, CJ, GAW, BG, LB, and JN provided comments and inputs to revise the manuscript.

Competing interests
None declared.

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Data sharing statement
Data are available upon reasonable request.

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Ethics approval
This study involves human participants. Ethics approval was obtained from the Rheinisch-Westfälische Technische Hochschule Aachen Human Ethics Research Committee (351/20).

Patient consent for publication
Not required.

REFERENCES

For peer review only

1 Nussbaumer-Streit B, Mayr V, Dobrescu AI, et al. Quarantine alone or in combination with other public health measures to control COVID-19: a rapid review. Cochrane Database Syst Rev 2020;9(9):CD013574.

2 Patel J, Fernandes G, Sridhar D. How can we improve self-isolation and quarantine for covid-19? BMJ 2021;372:n625.

3 Al-Hanawi MK, Angawi K, Alshareef N, et al. Knowledge, Attitude and Practice Toward COVID-19 Among the Public in the Kingdom of Saudi Arabia: A Cross-Sectional Study. Front Public Health 2020;8:217.

4 Hills S, Eraso Y. Factors associated with non-adherence to social distancing rules during the COVID-19 pandemic: a logistic regression analysis. BMC Public Health 2021;21(1):352.

5 Clark C, Davila A, Regis M, et al. Predictors of COVID-19 voluntary compliance behaviors: An international investigation. Glob Transit 2020;2:76–82.

6 Crane MA, Shermock KM, Omer SB, et al. Change in Reported Adherence to Nonpharmaceutical Interventions During the COVID-19 Pandemic, April-November 2020. JAMA 2021;325(9):883–85.

7 Lüdecke D, Knesebeck O von dem. Protective Behavior in Course of the COVID-19 Outbreak-Survey Results From Germany. Front Public Health 2020;8:572561.

8 Szwarcwald CL, Souza Júnior PRB de, Malta DC, et al. Adherence to physical contact restriction measures and the spread of COVID-19 in Brazil. Epidemiol Serv Saude 2020;29(5):e2020432.

9 Solomou I, Constantinidou F. Prevalence and Predictors of Anxiety and Depression Symptoms during the COVID-19 Pandemic and Compliance with Precautionary Measures: Age and Sex Matter. Int J Environ Res Public Health 2020;17(14).

10 Wang C, Pan R, Wan X, et al. Immediate Psychological Responses and Associated Factors during the Initial Stage of the 2019 Coronavirus Disease (COVID-19) Epidemic among the General Population in China. Int J Environ Res Public Health 2020;17(5).

11 Al-Sabbagh MQ, Al-Ani A, Mafrachi B, et al. Predictors of adherence with home quarantine during COVID-19 crisis: the case of health belief model. Psychol Health Med 2022;27(1):215–27.

12 Kunzler AM, Röthke N, Günthner L, et al. Mental burden and its risk and protective factors during the early phase of the SARS-CoV-2 pandemic: systematic review and meta-analyses. Global Health 2021;17(1):34.

13 Rajkumar RP. COVID-19 and mental health: A review of the existing literature. Asian Journal of Psychiatry 2020;52:102066.

14 Carlsen EØ, Caspersen IH, Trogstad L, et al. Public adherence to governmental recommendations regarding quarantine and testing for COVID-19 in two Norwegian cohorts. MedRxiv 2020.12.18.20248405 [Preprint]. December 20, 2020. [cited 2022 Sep 17]. https://doi.org/10.1101/2020.12.18.20248405.

15 Verberk JDM, Anthierens SA, Tonkin-Crine S, et al. Experiences and needs of persons living with a household member infected with SARS-CoV-2: A mixed method study. PLoS ONE 2021;16(3):e0249391.

16 Andrews N, Stowe J, Kirsebom F, et al. Covid-19 Vaccine Effectiveness against the Omicron (B.1.1.529) Variant. N Engl J Med 2022;386(16):1532–46.

17 Hsu L, Grüne B, Buess M, et al. COVID-19 Breakthrough Infections and Transmission Risk: Real-World Data Analyses from Germany's Largest Public Health Department (Cologne). Vaccines (Basel) 2021;9(11).

For peer review only

18 Joisten C, Kossow A, Book J, et al. How to manage quarantine-adherence, psychosocial consequences, coping strategies and lifestyle of patients with COVID-19 and their confirmed contacts: study protocol of the CoCo-Fakt surveillance study, Cologne, Germany. BMJ Open 2021;11(4):e048001.

19 Tong KK, Chen JH, Yu EW-Y, et al. Adherence to COVID-19 Precautionary Measures: Applying the Health Belief Model and Generalised Social Beliefs to a Probability Community Sample. Appl Psychol Health Well Being 2020;12(4):1205–23.

20 Rosenstock IM. The Health Belief Model and Preventive Health Behavior. Health Education Monographs 1974;2(4):354–86.

21 Carpenter CJ. A meta-analysis of the effectiveness of health belief model variables in predicting behavior. Health Commun 2010;25(8):661–69.

22 Neuhann F, Buess M, Wolff A, et al. Entwicklung einer Software zur Unterstützung der Prozesse im Gesundheitsamt der Stadt Köln in der SARS-CoV-2-Pandemie, Digitales Kontaktmanagement (DiKoMa). Epidemiologisches Bulletin 2020;2020(23):3–11.

23 Betsch C, Wieler L, Bosnjak M, et al. Germany COVID-19 Snapshot MOnitoring (COSMO Germany): Monitoring knowledge risk perceptions preventive behaviours and public trust in the current coronavirus outbreak in Germany. PsychArchives; 2020. Available at: https://doi.org/10.23668/psycharchives.2776 Accessed September 17, 2022.

24 World Health Organization. Home care for patients with suspected or confirmed COVID-19 and management of their contacts 2020. Available at: https://www.who.int/publications/i/item/home-care-for-patients-with-suspected-novel-coronavirus-(ncov)-infection-presenting-with-mild-symptoms-and-management-of-contacts Accessed September 17, 2022.

25 European Centre for Disease Prevention and Control. Infection prevention and control in the household management of people with suspected or confirmed coronavirus disease (COVID-19) 2020. Available at: https://www.ecdc.europa.eu/sites/default/files/documents/Home-care-of-COVID-19-patients-2020-03-31.pdf Accessed September 17,2022.

26 Robert Koch-Institut. Häusliche Isolierung bei bestätigter COVID-19-Erkrankung 2021. Available at: https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Flyer_Patienten.pdf?__blob=publicationFile Accessed September 17, 2022.

27 Kaduszkiewicz H, Kochen M, Pömsl J. Handlungsempfehlung Häusliche Isolierung von CoViD-19-Fällen mit leichtem Krankheitsbild und Verdachtsfällen 2020. Available at: https://www.degam.de/files/Inhalte/Leitlinien-Inhalte/Dokumente/DEGAM-S1-Handlungsempfehlung/053-054%20SARS-CoV-2%20und%20Covid-19/Publikationsdokumente%20Archiv/053-054_Empfehlungen%20Haeusliche_Isolierung.pdf Accessed September 17, 2022.

28 Lange C, Jentsch F, Allen J, et al. Data Resource Profile: German Health Update (GEDA)--the health interview survey for adults in Germany. Int J Epidemiol 2015;44(2):442–50.

29 Wang CC, Prather KA, Sznitman J, et al. Airborne transmission of respiratory viruses. Science 2021;373(6558).

30 German Federal Ministry of Health, Public Relations Division. Together against corona: How to protect ourselves against the coronavirus 2021. Available at: https://assets.zusammengegencorona.de/eaae45wp4t29/59kagmqA8AWs87Jo2VgpTf/f826234fc4d8d58a891c9d159d2627aa/BMG_Infoflyer_kurz_Corona_English.pdf Accessed September 17, 2022.

For peer review only

31 Lin Y, Hu Z, Alias H, et al. Quarantine for the coronavirus disease (COVID-19) in Wuhan city: Support, understanding, compliance and psychological impact among lay public. J Psychosom Res 2021;144:110420.

32 Broichhaus L, Book J, Feddern S, et al. Where is the greatest risk of COVID-19 infection? Findings from Germany's largest public health department, Cologne. PLoS ONE 2022;17(8):e0273496.

33 Al Zabadi H, Yaseen N, Alhroub T, et al. Assessment of Quarantine Understanding and Adherence to Lockdown Measures During the COVID-19 Pandemic in Palestine: Community Experience and Evidence for Action. Front Public Health 2021;9:570242.

34 Park CL, Russell BS, Fendrich M, et al. Americans' COVID-19 Stress, Coping, and Adherence to CDC Guidelines. J Gen Intern Med 2020;35(8):2296–303.

35 Smith LE, Potts HWW, Amlôt R, et al. Adherence to the test, trace, and isolate system in the UK: results from 37 nationally representative surveys. BMJ 2021;372:n608.

36 Cornesse C, Gonzalez Ocanto M, Fikel M, et al. Measurement instruments for fast and frequent data collection during the early phase of COVID-19 in Germany: reflections on the Mannheim Corona Study. Meas Instrum Soc Sci 2022;4(1).

37 Stadt Köln - Amt für Stadtentwicklung und Statistik. Kölner Zahlenspiegel 2020. Available at: https://www.stadt-koeln.de/mediaasset/content/pdf15/statistik-standardinformationen/k%C3%B6lner_zahlenspiegel_2020_deutsch.pdf Accessed September 17, 2022.

38 Madewell ZJ, Yang Y, Longini IM, et al. Household Transmission of SARS-CoV-2: A Systematic Review and Meta-analysis. JAMA Netw Open 2020;3(12):e2031756.

39 Telenti A, Arvin A, Corey L, et al. After the pandemic: perspectives on the future trajectory of COVID-19. Nature 2021;596(7873):495–504.

40 Loss J, Boklage E, Jordan S, et al. Risikokommunikation bei der Eindämmung der COVID-19-Pandemie: Herausforderungen und Erfolg versprechende Ansätze. Bundesgesundheitsblatt Gesundheitsforschung Gesundheitsschutz 2021;64(3):294–303.

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FOOTNOTES

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Legends:

Figure 1: Participants-Flow Chart

Figure 2: Relative distribution of implementation (left) and difficulty (right) of selected recommendations in domestic isolation and quarantine; separated for infected persons (IP) and their contacts (CP)

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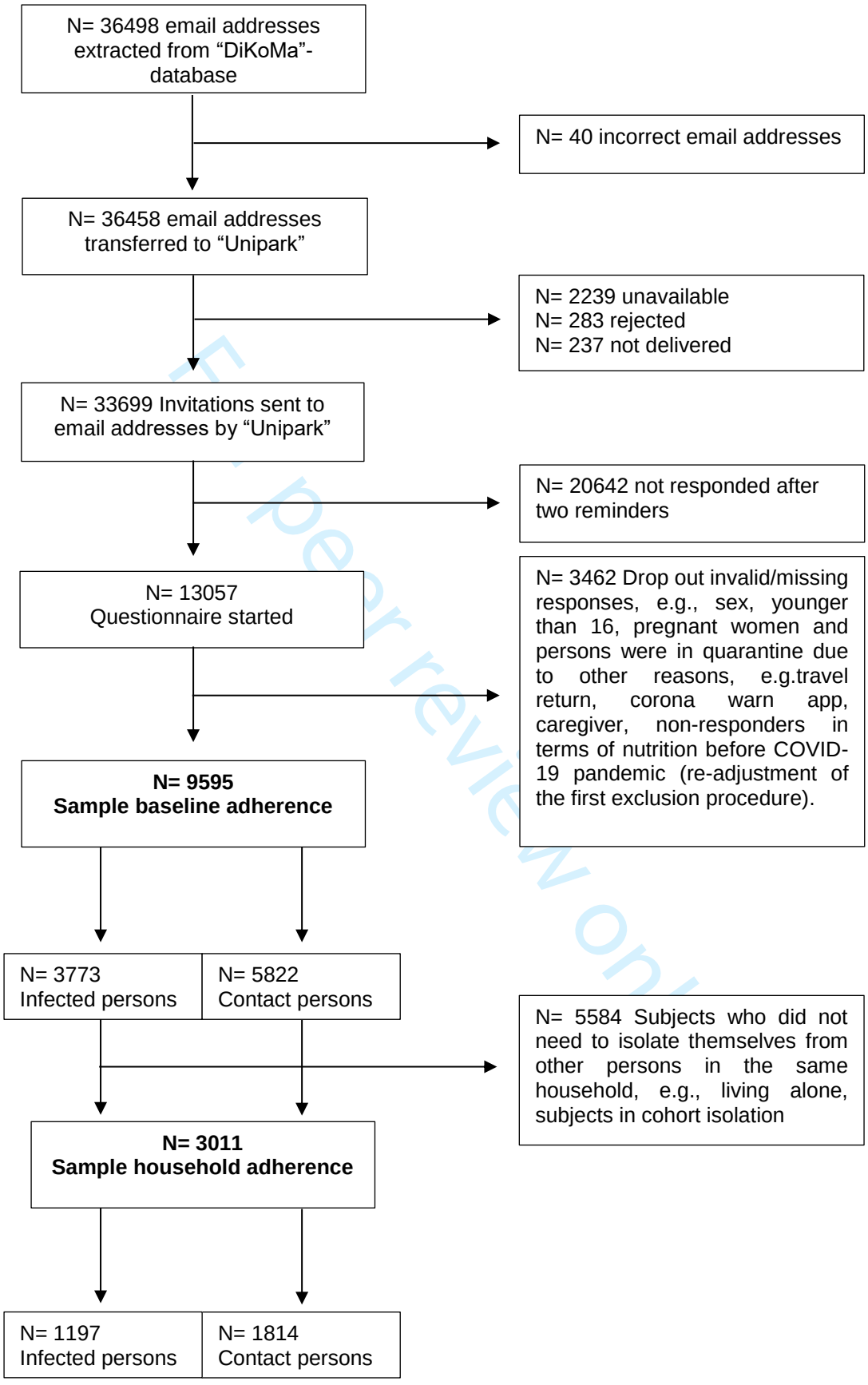

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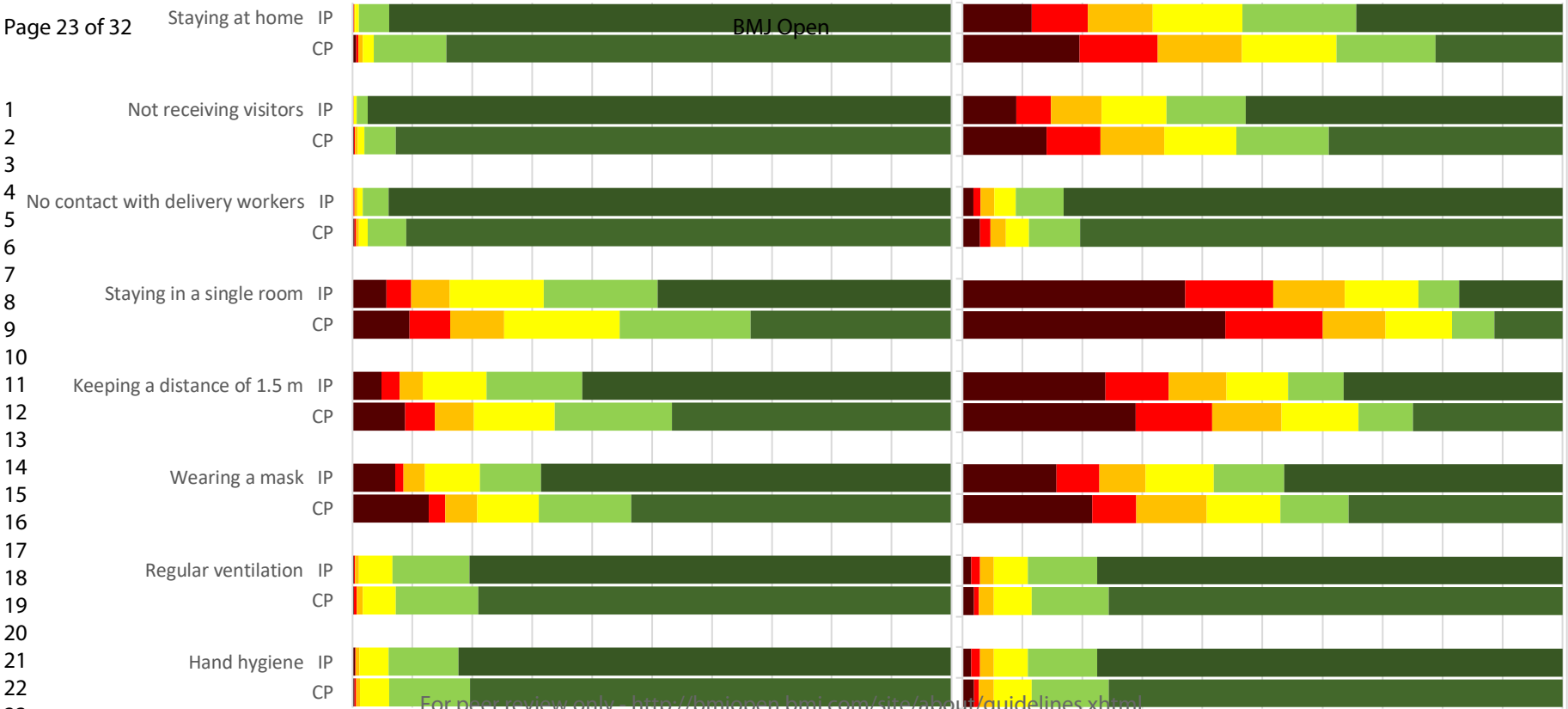

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SUPPLEMENTARY MATERIAL

Adherence to stay-at-home orders: awareness, implementation and difficulties of the officially ordered quarantine measures in the context of the COVID-19 pandemic in Cologne - a retrospective cohort study

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*Table S1: Awareness of isolation/quarantine recommendations. *(yes=1; no=2); CBR=Community based recommendation; HBR= Household based recommendation*

Recommendation			Infected persons			Contact persons			p-value
			N	Mean value *	SD	N	Mean value *	SD	
1	Do not leave your home.	CBR	3773	1.01	0.11	5822	1.02	0.14	.003
2	Do not receive visitors.	CBR	3773	1.01	0.10	5822	1.02	0.12	.009
3	Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.	CBR	3773	1.07	0.25	5822	1.12	0.32	<.001
4	Stay apart from other household members in a single room.	HBR	1184	1.06	0.24	1801	1.11	0.32	<.001
5	Sleep separately from other household members in a single room.	HBR	1182	1.12	0.33	1792	1.20	0.40	<.001
6	Have contact with other household members only when you need their help.	HBR	1173	1.19	0.39	1783	1.29	0.45	<.001
7	Keep at least a 1.5m distance when in contact with other household members.	HBR	1154	1.11	0.32	1772	1.16	0.37	<.001
8	Wear a mouth-nose mask when in contact with other household members.	HBR	1152	1.26	0.44	1767	1.37	0.48	<.001
9	Take your meals in a different room from other household members.	HBR	1145	1.20	0.40	1750	1.29	0.46	<.001
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	HBR	1144	1.19	0.39	1741	1.28	0.45	<.001
11	Use only one toilet. The rest of the household members should not use this toilet.	HBR	604	1.20	0.40	940	1.32	0.47	<.001
12	The bathroom you use should be cleaned at least once a day.	HBR	1142	1.47	0.50	1742	1.57	0.50	<.001
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	HBR	1133	1.38	0.49	1729	1.48	0.50	<.001
14	Air all rooms regularly.	HBR	1130	1.08	0.27	1729	1.10	0.30	.160
15	Sneeze into the crook of your elbow or a disposable handkerchief.	HBR	1124	1.03	0.16	1723	1.02	0.14	.327
16	Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.	HBR	1117	1.05	0.23	1715	1.05	0.21	.357
17	Collect tissues, gloves and other rubbish in a lidded bin in your room.	HBR	1112	1.56	0.50	1707	1.61	0.49	.018
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.	HBR	1107	1.35	0.48	1685	1.44	0.50	<.001
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.	HBR	1107	1.63	0.48	1693	1.69	0.46	<.001

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*Table S2: Implementation of isolation/quarantine recommendations. *(not implemented at all=1; fully implemented=6); CBR=Community based recommendation; HBR= Household based recommendation*

Recommendation			Infected persons			Contact persons			p-value
			N	Mean value *	SD	N	Mean value *	SD	
1	Do not leave your home.	CBR	3710	5.92	0.37	5656	5.78	0.65	<.001
2	Do not receive visitors.	CBR	3724	5.96	0.26	5703	5.89	0.46	<.001
3	Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.	CBR	3497	5.91	0.42	5090	5.86	0.52	<.001
4	Stay apart from other household members in a single room.	HBR	1105	4.85	1.47	1590	4.38	1.62	<.001
5	Sleep separately from other household members in a single room.	HBR	1031	5.49	1.33	1418	5.00	1.82	<.001
6	Have contact with other household members only when you need their help.	HBR	936	5.29	1.33	1261	4.95	1.55	<.001
7	Keep at least a 1.5m distance when in contact with other household members.	HBR	1010	5.15	1.38	1474	4.70	1.62	<.001
8	Wear a mouth-nose mask when in contact with other household members.	HBR	846	5.20	1.47	1104	4.73	1.75	<.001
9	Take your meals in a different room from other household members.	HBR	908	5.12	1.53	1230	4.56	1.86	<.001
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	HBR	922	5.06	1.47	1239	4.55	1.77	<.001
11	Use only one toilet. The rest of the household members should not use this toilet.	HBR	482	5.52	1.20	633	5.37	1.37	.057
12	The bathroom you use should be cleaned at least once a day.	HBR	601	5.30	1.22	741	5.18	1.34	.065
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	HBR	686	5.13	1.30	902	5.00	1.37	.071
14	Air all rooms regularly.	HBR	1028	5.72	0.65	1556	5.69	0.70	.275
15	Sneeze into the crook of your elbow or a disposable handkerchief.	HBR	1080	5.91	0.40	1681	5.88	0.47	.13
16	Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.	HBR	1048	5.74	0.65	1630	5.72	0.67	.363
17	Collect tissues, gloves and other rubbish in a lidded bin in your room.	HBR	485	5.64	0.95	667	5.59	1.02	.455
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.	HBR	715	5.66	0.83	942	5.61	0.86	.230
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.	HBR	408	5.26	1.39	515	5.11	1.49	.118

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*Table S3: Difficulty of isolation/quarantine recommendations. *(very difficult=1; not difficult at all=6); CBR=Community based recommendation; HBR= Household based recommendation*

Recommendation			Infected persons			Contact persons			p-value
			N	Mean value *	SD	N	Mean value *	SD	
1	Do not leave your home.	CBR	3722	4.24	1.74	5686	3.60	1.81	<.001
2	Do not receive visitors.	CBR	3729	4.72	1.69	5713	4.23	1.84	<.001
3	Avoid personal contact with postal and delivery workers and have deliveries left outside the house or flat entrance.	CBR	3499	5.64	0.97	5089	5.54	1.13	<.001
4	Stay apart from other household members in a single room.	HBR	1102	2.89	1.89	1583	2.55	1.77	<.001
5	Sleep separately from other household members in a single room.	HBR	1026	4.24	2.09	1409	3.91	2.17	<.001
6	Have contact with other household members only when you need their help.	HBR	938	4.02	2.00	1256	3.70	2.02	<.001
7	Keep at least a 1.5m distance when in contact with other household members.	HBR	1010	3.80	2.04	1467	3.35	1.97	<.001
8	Wear a mouth-nose mask when in contact with other household members.	HBR	843	4.36	1.90	1091	3.91	1.97	<.001
9	Take your meals in a different room from other household members.	HBR	904	3.90	1.99	1224	3.47	2.00	<.001
10	Use the bathroom, hallway, kitchen and other common areas only when absolutely necessary.	HBR	919	3.93	1.96	1233	3.49	1.99	<.001
11	Use only one toilet. The rest of the household members should not use this toilet.	HBR	481	5.31	1.46	627	5.20	1.50	.259
12	The bathroom you use should be cleaned at least once a day.	HBR	596	4.85	1.61	738	4.86	1.59	.905
13	Surfaces you frequently touch (bedside table, door handles, smartphone, work surfaces, etc.) should be cleaned once a day.	HBR	682	4.71	1.63	899	4.64	1.61	.353
14	Air all rooms regularly.	HBR	1030	5.57	0.98	1553	5.54	1.00	.483
15	Sneeze into the crook of your elbow or a disposable handkerchief.	HBR	1079	5.81	0.73	1679	5.80	0.75	.824
16	Wash your hands regularly for at least 20 seconds, especially after blowing your nose or sneezing.	HBR	1047	5.59	0.94	1631	5.64	0.86	.219
17	Collect tissues, gloves and other rubbish in a lidded bin in your room.	HBR	480	5.56	1.01	664	5.54	1.07	.675
18	After washing your hands, use paper towels or a towel that only you use, and change it daily.	HBR	716	5.56	1.00	940	5.54	0.97	.676
19	Wash your clothes at a minimum of 60 degrees and separately from the laundry of other household members.	HBR	401	5.12	1.52	512	4.99	1.55	.177

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*Table S4: Views on COVID-19 in relation to quarantine. Hypothetical factors influencing the use of preventive health measures according to the Health Belief Model with statements adapted to the COVID-19 pandemic and isolation/quarantine. Sample size, mean value of agreement and standard deviation (SD) are shown separately for index persons and contact persons. P-value is given for the t-test for independent samples. * (1≙I do not agree at all; 6 ≙I fully agree); ** (1 ≙ yes; 2≙no)*

Influencing factor according to the Health Belief Model	Statement or question adapted to the COVID-19 pandemic and isolation/quarantine	Infected persons			Contact persons			P-Value
		N	Mean value	SD	N	Mean value	SD	
Perceived Severity/ Perceived Susceptibility	I think the coronavirus is dangerous.	3750	5.4*	1.1	5784	5.5*	0.9	<.001
Perceived Benefits	When I isolate/quarantine myself, I am protecting myself.	3685	3.7*	2.1	5730	3.9*	2.0	.008
	When I isolate/ quarantine myself, I am protecting other members of my household.	3712	4.6*	1.8	5725	4.4*	1.9	<.001
	When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus.	3748	5.8*	0.7	5790	5.8*	0.7	<.001
Perceived Barriers	I experienced difficulties in obtaining everyday necessities during isolation/quarantine	3748	2.4*	1.7	5781	2.3*	1.7	.061
	I suffered financial losses due to the isolation/quarantine (yes/no)	3239	1.8**	0.4	4956	1.8**	0.4	.271
Expected Result	I think the isolation/ quarantine measures are too strict.	3724	2.2*	1.7	5757	2.5*	1.7	<.001
	I think the quarantine measures are too lax.	3696	2.4*	1.7	5697	2.4*	1.6	.200
Psychological characteristics/ Peer group pressure	People in my professional and social environment have expected me to implement the quarantine measures.	3706	5.5*	1.2	5732	5.3*	1.3	<.001
Health Knowledge/ Cue to action	I have been given clear information about the reason for the isolation/quarantine.	3742	5.3*	1.3	5786	4.8*	1.7	<.001
	It was explained to me in an understandable way how to behave in isolation/quarantine.	3746	5.1*	1.4	5774	4.7*	1.7	<.001

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Table S5: Distribution of the baseline adherence score

Baseline adherence score (points)	Infected persons		Contact persons		Total	
	N	%	N	%	N	%
0	17	0.5	51	0.9	68	0.7
>0-3	3	0.1	10	0.2	13	0.1
>3-6	24	0.6	89	1.5	113	1.2
>6-9	45	1.2	214	3.7	259	2.7
>9-11	295	7.8	688	11.8	983	10.2
>11-14	371	9.8	993	17.1	1364	14.2
15	3018	80.0	3777	64.9	6795	70.8

Table S6: Distribution of the household adherence score

Household adherence score (points)	Infected persons		Contact persons		Total	
	N	%	N	%	N	%
0	25	2.1	42	2.3	67	2.2
>0-5	52	4.3	105	5.8	157	5.2
>5-10	119	9.9	253	13.9	372	12.4
>10-15	191	16.0	373	20.6	564	18.7
>15-20	259	21.6	419	23.1	678	22.5
>20-24	278	23.2	348	19.2	626	20.8
25	273	22.8	274	15.1	547	18.2

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*Table S7: Factors influencing the baseline and household adherence score. Baseline models of linear backward regression analyses *(disagree=1; agree=2)*

Baseline models	Non-Standardised Coefficients		Standardised Coefficients		95% Confidence Interval	
	Regression Coefficient (B)	Std. Error	Beta	Sig.	Lower Limit	Upper Limit
Baseline adherence score						
Infected persons (1) vs. Contact persons (2)	-0.030	0.003	-0.102	<.001	-0.037	-0.024
Age (years)	0.001	0.000	0.055	<.001	<0.001	0.001
Gender (female=1; male=2)	-0.001	0.003	-0.002	.860	-0.007	0.006
Migration background (no= 1; yes=2)	0.012	0.008	0.017	.133	-0.004	0.027
Socioeconomic status (SES) (high=1; middle and low=2)	-0.007	0.004	-0.018	.116	-0.016	0.002
Comorbidity (yes=1; no=2)	0.002	0.004	0.004	.708	-0.007	0.010
Married/ living in a Relationship (no=1; yes=2)	-0.001	0.004	-0.003	.791	-0.009	0.007
Having Children (yes=1; no=2)	-0.010	0.004	-0.033	.023	-0.018	-0.001
Access to balcony or garden (yes=0; no=1)	-0.002	0.005	-0.006	.640	-0.012	0.007
I think the coronavirus is dangerous. *	0.011	0.008	0.017	.175	-0.005	0.027
When I isolate/quarantine myself, I am protecting myself. *	0.004	0.004	0.013	.268	-0.003	0.011
When I isolate/ quarantine myself, I am protecting other members of my household. *	0.012	0.004	0.038	.002	0.005	0.020
When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus.*	0.044	0.013	0.041	.001	0.019	0.070
I experienced difficulties in obtaining everyday necessities during isolation/quarantine *	-0.015	0.004	-0.044	<.001	-0.023	-0.007
I suffered financial losses due to the isolation/quarantine (yes=1; no=2)	-0.005	0.004	-0.012	.294	-0.013	0.004
I think the isolation/ quarantine measures are too strict. *	-0.016	0.004	-0.048	<.001	-0.024	-0.008
I think the isolation/ quarantine measures are too lax. *	-0.012	0.004	-0.037	.002	-0.020	-0.005
People in my professional and social environment have expected me to implement the quarantine measures. *	0.037	0.006	0.070	<.001	0.025	0.049
I have been given clear information about the reason for the isolation/quarantine. *	0.007	0.006	0.017	.244	-0.005	0.018
It was explained to me in an understandable way how to behave in quarantine. *	0.047	0.006	0.125	<.001	0.036	0.058
Household adherence score						
Infected persons (1) vs. Contact persons (2)	-0.052	0.010	-0.102	<.001	-0.072	-0.032
Age (years)	0.002	0.001	0.104	<.001	0.001	0.003
Sex (female=1; male=2)	0.023	0.010	0.046	.023	0.003	0.043
Migration background (no= 1; yes=2)	0.067	0.022	0.060	.003	0.023	0.110

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Socioeconomic status (SES) (high=1; middle and low=2)	-0.028	0.012	-0.045	.024	-0.053	-0.004
Comorbidity (yes=1; no=2)	-0.006	0.012	-0.010	.608	-0.030	0.018
Married/ living in a Relationship (no=1; yes=2)	0.064	0.014	0.101	<.001	0.036	0.091
Having Children (yes=1; no=2)	-0.029	0.013	-0.058	.029	-0.054	-0.003
Access to balcony or garden (yes=0; no=1)	-0.015	0.017	-0.017	.391	-0.048	0.019
I think the coronavirus is dangerous. *	0.055	0.023	0.049	.019	0.009	0.101
When I isolate/quarantine myself, I am protecting myself. *	0.008	0.010	0.015	.455	-0.012	0.028
When I isolate/ quarantine myself, I am protecting other members of my household. *	0.142	0.013	0.236	<.001	0.117	0.167
When I isolate/ quarantine myself, I am protecting our society from a further spread of the coronavirus.*	0.069	0.042	0.034	.099	-0.013	0.150
I experienced difficulties in obtaining everyday necessities during isolation/quarantine *	-0.004	0.012	-0.006	.766	-0.028	0.021
I suffered financial losses due to the isolation/quarantine (yes=1; no=2)	-0.025	0.013	-0.040	.049	-0.049	<0.001
I think the isolation/ quarantine measures are too strict. *	-0.015	0.012	-0.026	.201	-0.038	0.008
I think the isolation/ quarantine measures are too lax. *	-0.012	0.011	-0.022	.276	-0.035	0.010
People in my professional and social environment have expected me to implement the quarantine measures. *	0.007	0.019	0.007	.729	-0.031	0.045
I have been given clear information about the reason for the isolation/quarantine. *	0.040	0.017	0.057	.019	0.007	0.074
It was explained to me in an understandable way how to behave in quarantine. *	0.032	0.016	0.048	.047	0.000	0.064

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STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	3-4
Methods			
Study design	4	Present key elements of study design early in the paper	4-5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-5
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4-5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*4-8*
Bias	9	Describe any efforts to address potential sources of bias	4-8
Study size	10	Explain how the study size was arrived at	(Fig. 1)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	8
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	8
		(*e*) Describe any sensitivity analyses	8
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	(Fig.1)
		(b) Give reasons for non-participation at each stage	(Fig.1)
		(c) Consider use of a flow diagram	Fig. 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	(Tab. 2)
		(b) Indicate number of participants with missing data for each variable of interest	9, Fig. 1, Tab. 2
Outcome data	15*	Report numbers of outcome events or summary measures	8-13

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	8-13
		(*b*) Report category boundaries when continuous variables were categorized	not applicable
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-13
Discussion			
Key results	18	Summarise key results with reference to study objectives	2-4, 13-16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-16
Generalisability	21	Discuss the generalisability (external validity) of the study results	13-16
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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