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RESEARCH ARTICLE

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Impact of the COVID-19 lockdown on system usage of an innovative care support system and the mood of older adults

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Abstract

Background: Older age is a substantial risk factor for serious illness from COVID-19. Moreover, isolation and quarantine are more likely to cause physical, mental and social deprivation in older age. Information and Communication Tools are means to prevent such consequences.

Objective: This study aimed therefore to investigate the impact of the COVID-19 lockdown measures on the usage of an innovative technical support system deployed in Austria (AT) and Luxembourg (LU) consisting of several tools that allow independent living in older age.

Methods: Thirty-nine older adults (11 male; 28 female) with a mean age of 74.3 (SD 7.3) years were included in the study. In total, 18 older people were recruited in AT and 21 in LU. Descriptive statistics were computed, and longitudinal models were fitted for technology use and self-reported mood.

Results: The number of older adults using the system significantly decreased from the time before lockdown (39 [100%]) to during lockdown (26 [67%]) and thereafter (23 [59%]; $p < 0.001$). Multiple comparisons revealed a significant reduction in the average number of events for calendar and medication tools, but a substantial increase in communication and messaging events. Self-reported well-being declined during the lockdown and increased afterwards back to baseline levels.

Conclusion: Communication was the main reason for using the support system. In addition, strategies and interventions are essential to support older adults when using information technology in the prolonged phases of the pandemic to sustain independent living.

Clinical trial registration: The DAPAS protocol was published at www.researchgate.net. DOI: 10.13140/RG.2.2.24233.34401.

Christopher C. Mayer and Erika Mosor are joint first authors.

KEYWORDS
assistive technology, communication, coronavirus, new technology, older people, participation, vulnerable

Key points

- Social isolation and quarantine are more likely to cause physical, mental and social deprivation in older age; Information and Communication Tools (ICTs) could help to prevent such consequences.
- This study investigated the impact of the COVID-19 lockdown measures on using an innovative technical support system and the self-reported mood of older adults at times of reduced social contact.
- In general, the number of older adults using the novel system significantly decreased during the lockdown, but there was a substantial increase in communication and messaging events.
- Self-reported well-being declined during the lockdown and increased afterwards back to baseline levels.

1 | INTRODUCTION

The outbreak of COVID-19 affects all people around the globe. Vulnerable groups are most affected, often in a multifaceted way. This also includes older adults, not only due to the higher prevalence of chronic diseases[1] often leading to life-threatening manifestations of COVID-19, but also due to the direct impact on their ability to access services and goods and due to social isolation.[2] Social isolation and loneliness affect – even without COVID-19 and the related lockdowns – a significant part of the older adult population and present a not negligible but underappreciated public health risk.[3] In general, 7% of all European adults of all ages report being frequently lonely.[4] However, social isolation primarily concerns older adults as it increases with age. In 2016, 18% of EU citizens aged 65 or older reported to feel frequently lonely.[4] In certain countries, such as Romania and Bulgaria, 2 in 10 older people reported being alone all or most of the time.[4] Twenty-five percent of community-dwelling Americans older than 65 years of age are considered socially isolated.[3] There is evidence that numerous negative health outcomes are related to social isolation.[5] Virtual contacts being complementary rather than substituting personal contacts might be a good means to reduce loneliness and social isolation.[6]

Recently, health and social care providers have started to use Information and Communication Tools (ICTs) for care provision and increase of efficiency.[7] Understandably, older adults have reported a strong preference to live independently.[8] Accordingly, there is growing interest of public and private care organisations in assistive technologies, which maintain safety and enhance health and psychological well-being in older adults.[9] Those technologies successfully contribute to all dimensions of the quality of life in older adults.[10] While most ICT-based systems were designed to support older adults before the COVID-19 pandemic, their functionalities could be even more useful during a lockdown. The use of ICTs, in general, may help to overcome some of the typical problems of community-dwelling older adults, such as increased social isolation and loneliness recently experienced during the lockdown with an abrupt start of social distancing and a slow return to the 'new normality'. Public health can benefit from digital tools, which have proven their potential in the current crisis, but their widespread use may be hindered.[11] One reason for this is less attention to vulnerable populations and older adults who might have limited access to digital technologies and lower health literacy.[12,13] There is only limited knowledge if and how such ICT-based services were used by older adults before, during and after the lockdown (After-LD). Initial evidence of uptake of communication technology during lockdown highlights the benefit of these tools as an association with better emotional health and quality of life was observed.[14] In addition, there has been no investigation of the influence of reduced support from informal or formal caregivers on older adults' use of new technologies during a crisis.

In the context of the DAPAS ("Deploying AAL Packages At Scale") project, an innovative care support system for older adults and their caregivers was developed, implemented and evaluated.[15] The basic functionalities of the supporting technology are described in the "Material and Methods" section. The evaluation started in January 2020 and had been affected by the COVID-19 pandemic and the concomitant measures taken to mitigate the spread of the coronavirus. In Austria (AT) and Luxembourg (LU), the lockdown came into effect in mid-March 2020, leading to restrictions in mobility, health care and many other areas of daily life. Especially, geriatric institutions and caregivers were limited in their daily work due to strict measures, such as visiting bans or prohibition of house calls, to protect older adults. These measures were much longer in place than those for the general public, which were mostly eased by the end of April 2020.

To the best of our knowledge, no studies have investigated the influence of the pandemic and the associated lack of support in using innovative care support systems for older adults and their potential impact on mental health during the early and later phases of the pandemic. Nevertheless, the DAPAS system provides certain functions

to support older adults during the pandemic. Thus, the primary aim of this study was to investigate the impact of the COVID-19 lockdown on the usage of an innovative care support system supporting older adults in their daily life. Furthermore, this study describes the influence of the lockdown on the self-reported mood of the older persons who have used the innovative care support system before, during and after the COVID-19 lockdown.

2 | MATERIAL AND METHODS

2.1 | Study population

Data used in this work are a subset from the DAPAS study.[16] The study protocol was approved by the local ethics committees, the study adhered to the Declaration of Helsinki,[17] and all patients gave oral and written informed consent. The dataset for this study included data from all older adults who had been included in the DAPAS study before the pandemic and started using the DAPAS support system. Participants in AT and LU were recruited by the two user organisations (Red Cross Styria [AT] and Stëftung Hëllef Doheem [LU]) between January and March 2020. Data until June 2020 were used for this study.

The number of participants for the DAPAS study was powered to explore a potential effect of the DAPAS system. As the study was affected by the COVID pandemic, for example, recruitment and installation for further editions of the DAPAS support system had to be delayed due to the lockdowns in the respective countries, we decided to use the already existing data to analyse how the pandemic influenced the use of the DAPAS system. No selection was made and all study participants using the DAPAS system were included.

2.2 | The deploying AAL packages at scale system

The DAPAS system is a solution for people with need for care as primary end-users and their involved caregivers, either informal or formal ones. It aims to deliver an innovative solution based on the needs of older adults and their caregivers to improve older adults' lives and their ability to be more independent from others through the use of information and communication technology. The solution is designed to create a sense of security, to support people who need specific care in their daily living, and to increase communication. The basic functions of the system are: communication via video call and messaging for staying in contact with family, friends, and caregivers (i.e., receiving and launching/sending video calls and messages including pictures from and to the DAPAS team of healthcare professionals, caregivers and other peers); a brain training game to maintain and stimulate cognitive and mental performance (i.e., selecting the correct word from a group of depicted ones as fast as possible); a calendar as a shared planning aid for appointments and exercises (i.e., displaying all information i.e., considered important for the user to remember, such as planned health checks or visits); medication reminders (i.e., extending the calendar function with special focus on medication management and reminders); contact management (i.e., offering the possibility to add, edit and delete contacts from the DAPAS system to be used for communication); and a self-reported mood-function (i.e., allowing the users to set their well-being status on a daily basis). All participants used the DAPAS system running on Android on a Huawei MediaPad T5.

2.3 | Data collection regarding device usage and the current mood of older adults

For device usage, services implemented in the Flurry Analytics Software Development Kit[18] including the provided cloud backend, were used. It can be used to track screen transitions and includes information about the current screen to the logging events. This allows the determination of different metrics, such as the number of active users or the average number of events per user per week, for different timeframes. Events are defined as All events, communication, Bingo (game), calendar, medication, contact, screen view, and messages. In addition, data on the current mood of older adults are automatically logged by the DAPAS devices based on a daily subjective assessment. Older people answer the question "How are you?" with answer possibilities on a 5-item Likert scale ranging from very good (1) to very bad (5) on a daily basis. Events averaged per week and participant and number of participants using the system were analysed in the following timeframes: (i) before the time of lockdown (Before-LD), from the first use of the system to the 16 March 2020, (ii) during lockdown (LD), between the 17 March and the 27 April 2020, and (iii) After-LD, between the 28 April and the 15 June 2020, see Figure 1. We differently determined the timeframes for analysing the mood data as we aimed to specifically look at the transition points (changing from normal life to lockdown and back again). Thus, mood parameters are compared at: (i) Baseline (defined as 5 weeks after the first participant in), (ii) start of lockdown (3 weeks around start of lockdown), (iii) end of lockdown (3 weeks around lockdown end) and (iv) Final (last 5 weeks of data logging); details can be found in Figure 1. Non-essential businesses were closed in AT from the 16 March till 13 April 2020 and in LU from the 18 March till the 20 April 2020 with a further stay-home-order in AT till the 1 May 2020. In both countries, the mitigation measures for COVID-19 have been applied nationwide. For data from the project on policy responses to the coronavirus pandemic related to the level and timing of restrictions,[19] see Figure 2A,C. These restrictions are coherent with mobility data,[20] see Figure 2B,D. Due to the vulnerability of older adults, various measures such as visiting bans in geriatric facilities were much longer in place.

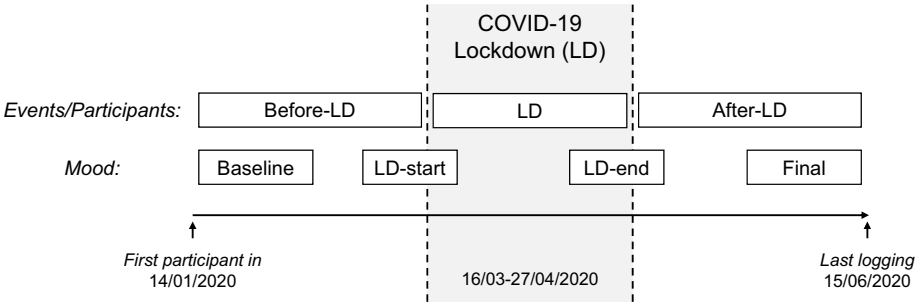

FIGURE 1 Definition of time periods. LD, lockdown

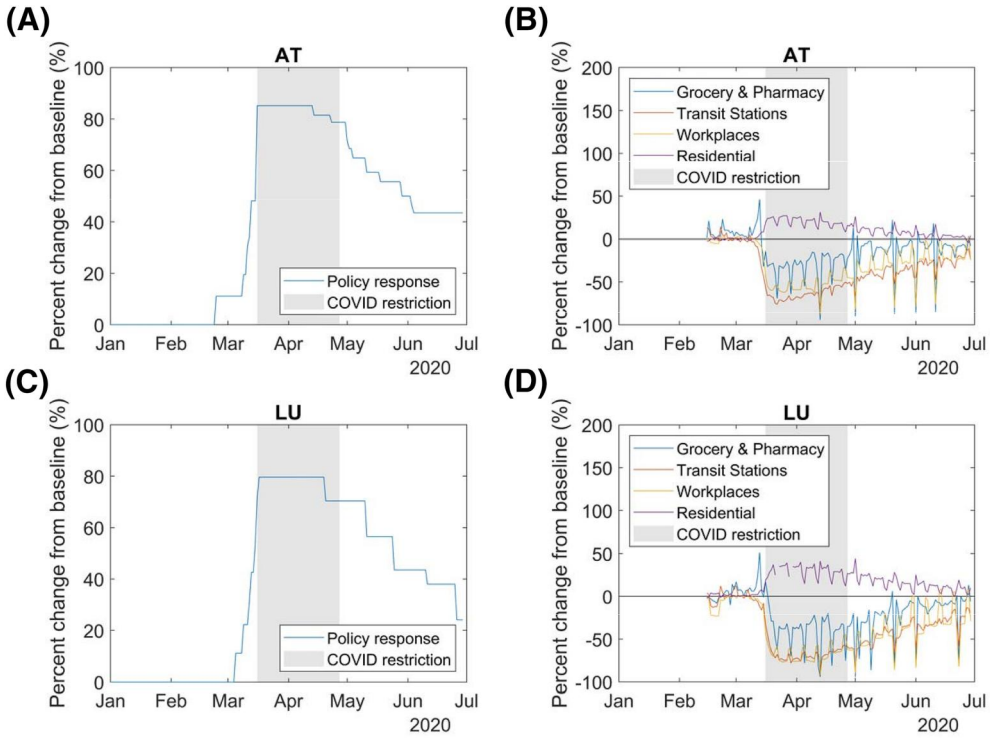

FIGURE 2 Policy response and mobility data. Policy response (A, C) and mobility (B, D) data for Austria (A, B) and Luxembourg (LU) (C, D) (Source:[19,20]). Policy response is defined by the Oxford Coronavirus Government Response Tracker based on publicly available information. It is a combination of 17 indicators of government responses, spanning containment and closure policies (e.g., school closures and restrictions in movement), economic policies, and health system policies (e.g., testing regimes).[19] AT, Austria; LU, Luxembourg

2.4 | Statistical analysis

Continuous data are tested for normality using the Kolmogorov–Smirnov test. Based thereupon, these data are presented as mean (standard deviation) or median (inter-quartile range). Categorical data are presented as total number (percentage). Device usage data for the three timeframes are compared using analysis of variance (ANOVA) for normally distributed data (as given or log-transformed), or by means of the Kruskal–Wallis test, as appropriate. Post-hoc analysis is performed using Scheffé test for ANOVA or pairwise comparison with Holm–Bonferroni correction for Kruskal–Wallis. Interaction analysis is done via interaction terms. Categorical data are compared using Cochran's Q test and post-hoc testing based on calculating a minimum required difference for a significant difference between two proportions accounting for multiple testing.[21] To compare mood data for complete data sets (i.e., data of participants for all four timeframes available), the exact Friedman test with Bonferroni correction for multiple testing for post-hoc comparison is used. Statistical significance was assumed at a 5% level. Statistical analysis was performed using Matlab R2019b (The MathWorks, Inc).

3 | RESULTS

3.1 | Descriptive characteristics of study participants

In the analyses, 39 older adults (11 [28%] male; 28 [72%] female) with a mean age of 74.3 (SD 7.3) years were included. In total, 18 (46%) older people were recruited in AT and 21 (54%) in LU. Only one participant stopped participation after 2 weeks of inclusion. We did not include these data in the demographics and our analysis. Baseline characteristics can be found in Supplementary Table 1.

3.2 | Event data

The number of older adults using the DAPAS system significantly decreased comparing Before-LD, LD and After-LD (39 [100%] vs. 26 [67%] vs. 23 [59%], $p < 0.001$). The minimum required difference for a significant difference between two proportions accounting for multiple testing was 20.7%, which was reached for the pairwise comparisons Before-LD versus LD (33%; $p < 0.001$) and Before-LD versus After-LD (41%; $p < 0.001$), but not for LD versus After-LD (8%; $p = 0.54$). The number of participants using the different functionalities of the DAPAS system over time can be seen in Table 1. For

TABLE 1 Number of participants using the different functionalities of the deploying AAL packages at scale (DAPAS) system

Number of participants using specific functionalities of DAPAS	Before-LD	LD	After-LD	*p*-Value	CDc	Differences[a]
All events, *n* (%)	39 (100%)	26 (67%)	23 (59%)	<0.001	20.7%	33%***
						41%***
						8%
Communication events, *n* (%)	31 (79%)	11 (28%)	4 (10%)	<0.001	26.5%	51%***
						69%***
						18%*
Bingo events, *n* (%)	28 (72%)	15 (38%)	8 (21%)	<0.001	25.1%	33%**
						51%***
						18%
Calendar events, *n* (%)	37 (95%)	15 (38%)	9 (23%)	<0.001	27.0%	56%***
						72%***
						15%*
Medication events, *n* (%)	37 (95%)	20 (51%)	10 (26%)	<0.001	26.0%	44%***
						69%***
						26%**
Contact events, *n* (%)	36 (92%)	16 (41%)	7 (18%)	<0.001	28.4%	51%***
						74%***
						23%*
Screen view events, *n* (%)	38 (97%)	19 (49%)	13 (33%)	<0.001	25.1%	49%***
						64%***
						15%*
Messages events, *n* (%)	30 (77%)	4 (10%)	3 (8%)	<0.001	26.5%	67%***
						69%***
						3%
Mood button events, *n* (%)	38 (97%)	22 (56%)	20 (51%)	<0.001	22.4%	41%***
						46%***
						5%

Abbreviations: CDc, calculated minimum required difference for a significant difference between two proportions (corrected); LD, lockdown; *n* (%), number of participants.

[a]Differences are presented in the following order: (1) Before-LD versus LD, (2) Before-LD versus After-LD and (3) LD versus After-LD.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

TABLE 2 Average number of events per active user per week

Average number of events per active user per week	Before-LD (1)	LD (2)	After-LD (3)	*p*-Value	Post-hoc[a]
All events (#)	138 [75.6,215]	80.6 [31.3,145]	36.1 [16,84.9]	<0.001	(1–2) (1–3) (2–3)
Communication events (#)	3.75 [3,10]	14 [2.63,29]	23.5 [5.5,51]	0.14	‡
Bingo events (#)	7.43 (6.41 SD)	6.48 (6.92 SD)	9.54 (7.79 SD)	0.59	‡
Calendar events (#)	7.94 (5.35 SD)	3.58 (2.97 SD)	3.65 (2.49 SD)	0.003	(1–2) (1–3)
Medication events (#)	5 [2.5,10]	2.5 [1.63,5.38]	3.2 [2,4.67]	0.01	(1–2)
Contact events (#)	6.67 [3.13,14.9]	6.58 [4,7]	3 [3,6.67]	0.19	‡
Screen view events (#)	58.5 (54.6 SD)	39.2 (41.2 SD)	37.9 (45.3 SD)	0.26	‡
Messages events (#)	3.25 [2.5,6]	6 [4,10]	24 [7.5,34.5]	0.06	‡
Mood button events (#)	3.9 [2,5.5]	3.25 [2.25,5]	2 [1,4.52]	0.06	‡

Abbreviation: LD, lockdown.

[a]For pairwise post-hoc analyses, significant differences after correction for multiple testing are presented, where 1… Before-LD, 2 … LD and 3 … After-LD.

‡ … not performed, since $p > 0.05$, or no significant pairwise differences.

each separate functionality, the number of participants was again significantly different for the three timeframes ($p < 0.001$). Corrected pairwise comparison highlighted a highly significant drop from Before-LD to LD (as well as to After-LD) and partly significant decrease from LD to After-LD (e.g., Communication or medication events), but not for All events, Messages, and Mood Button events; see Table 1.

Multiple comparison reveals significant differences in the average number of events per active user per week for All events, Calendar, and Medication events, see Table 2. In parallel with the decrease of participants using these functionalities, we saw a decrease in the average number of events. For Communication and Messages events, the trend is opposite with an increase of the average number of events per active user per week during LD and After-LD (borderline significantly different for Message events: 3.25 [2.5,6] Before-LD, 6 [4,10] during LD, and 24 [7.5,34.5] After-LD, $p = 0.06$; visible trend but not significant for Communication events: 3.75 [3,10] vs. 14 [2.63,29] vs. 23.5 [5.5,51]; $p = 0.14$). For details, see Table 2.

There is no significant interaction with sex or country for all event types, except for Messages events ($p < 0.001$ for both factors). Data for events and number of participants per functionality stratified for country and sex can be found in Supplementary Tables 2 and 3. In Figure 3, one can see exemplarily the average number of All events (A) and Communication (B) events per active user per week overtime for single users and stratified for country with two Austrian users extremely standing out.

3.3 | Data on the mood of older adults

In Figure 4A, subjective mood data per person and, on average, are displayed. A trend for declining mood during COVID-19 lockdown could be seen, whereas mood increased after relaxation of restrictions again. This trend is further reflected in the results from Friedman test ($\chi^2(3) = 6.82$; $p = 0.08$) for $n = 14$ participants with complete datasets (i.e., at least one self-reported mood data in each of the four timeframes) with a decrease of mood between start and end of the lockdown ($p = 0.07$, Bonferroni corrected), see Box plots in Figure 4B. Subjective mood values are at baseline 2.33 [1.96,2.86], at LD-start 2.34 [2.00,2.76], at LD-end 2.70 [2.00,3.22] and finally 2.43 [2.00,3.00]. Similar trends are visible in mood data stratified by sex and country (see Supplementary Table 4).

4 | DISCUSSION

The primary aim of this study was to investigate the impact of the COVID-19 lockdown on the usage of a system supporting older adults in their daily life. We compared data before the lockdown with data during the lockdown and thereafter. Unexpectedly, all functionalities of the DAPAS support system showed a reduced utilisation during and After-LD compared to the time before, except for messaging and communication which increased during that time. The increasing or decreasing trend for the average number of events per active user per week depended on the type of events. Furthermore, a significant drop in the self-reported mood of older adults during the COVID-19 lockdown could be seen.

In general, there is a clear trend for fewer participants using the DAPAS system during and after lockdown. This trend is reflected by the absolute numbers of participants interacting with the system and the different functionalities, as by the average number of events per active user per week. This trend aligns with the mobility data[20] presented in (Figure 2B,D). One explanation for this phenomenon is that formal and informal caregivers had to reduce their personal visits during the lockdown and therefore could not support the older adults in using the DAPAS system, for example, by entering reminders for

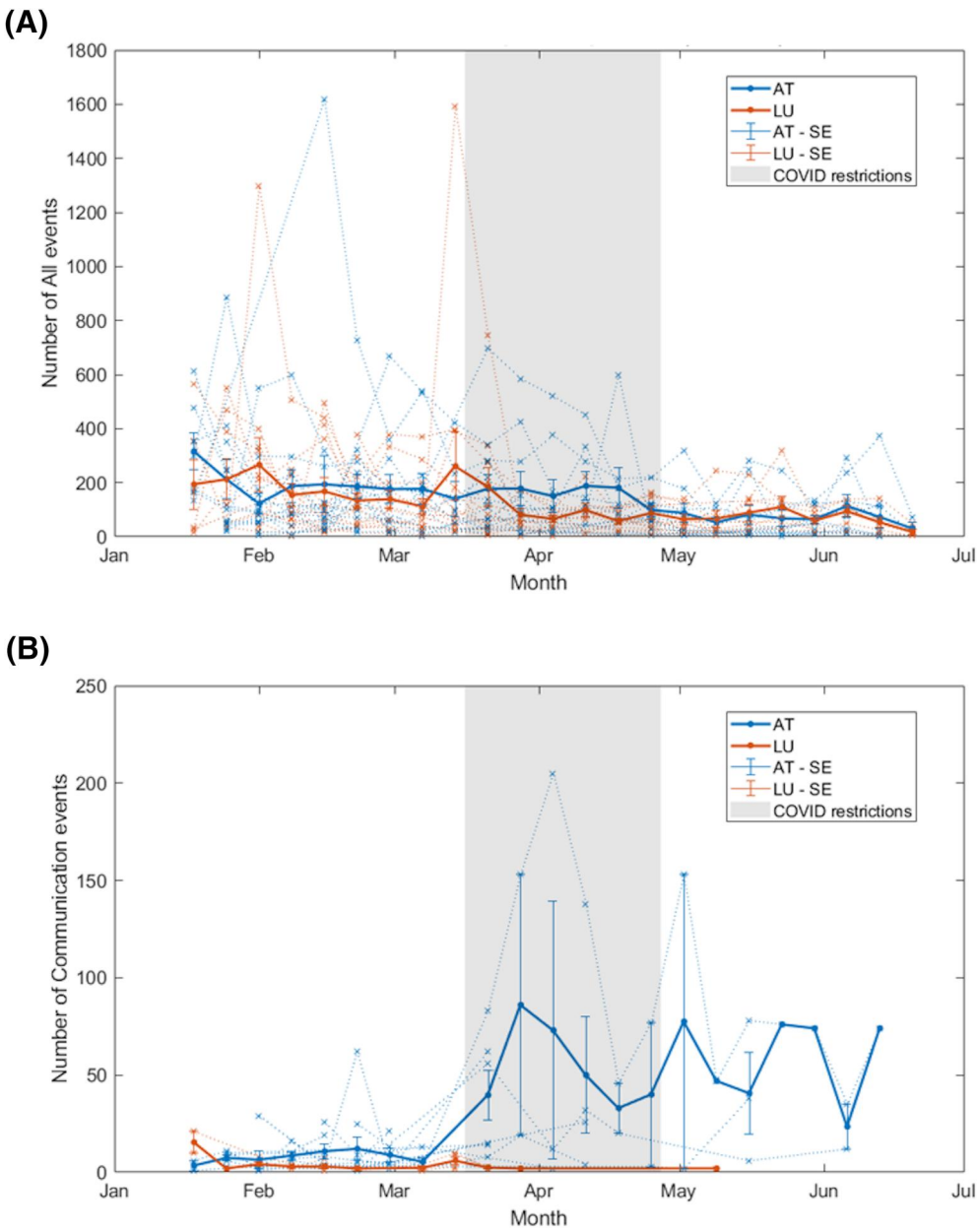

FIGURE 3 Average number of (A) All events and (B) Communication events per active user per week over time. Average number of All events and Communication events per active user per week over time (dashed lines) plus average (including standard error) over all participants (solid line) for Austria (blue) and Luxembourg (red). AT, Austria; LU, Luxembourg; SE, standard error

them or explaining different features. In contrast to mobility data showing a slow return to the 'new normality' After-LD in the general population (Figure 2B,D), regulations for user organisations regarding visits to geriatric institutions, house calls, etc. were still ongoing. The return to normal operation took much longer. Even after the data lock, the regulations in the facilities were far from being normal. Due to the continuing spread of the coronavirus, the still unavailable vaccination and the fear of a second wave of infection, there are still numerous restrictions in place reducing the frequency of personal contact. Moreover, the number of external appointments decreased dramatically during the complete lockdown and increased only slowly afterwards. This fact could explain the limited use of the calendar function. Another explanation for the reduced use of the new technology might be the short period of active usage of the DAPAS system by the older adults before starting the COVID-19 pandemic. People included in the study had started using the support system only a few weeks before lockdown. There might have been not enough time for appropriate training, and thus using the new technology might not have been sufficiently integrated into people's daily routine. Furthermore, another plausible and possible explanation could be that the novelty of the system wore off over the study period or could even be a reason for initially higher usage.

Notwithstanding, the Communication and Messages events – but not the other events – increased during the lockdown and

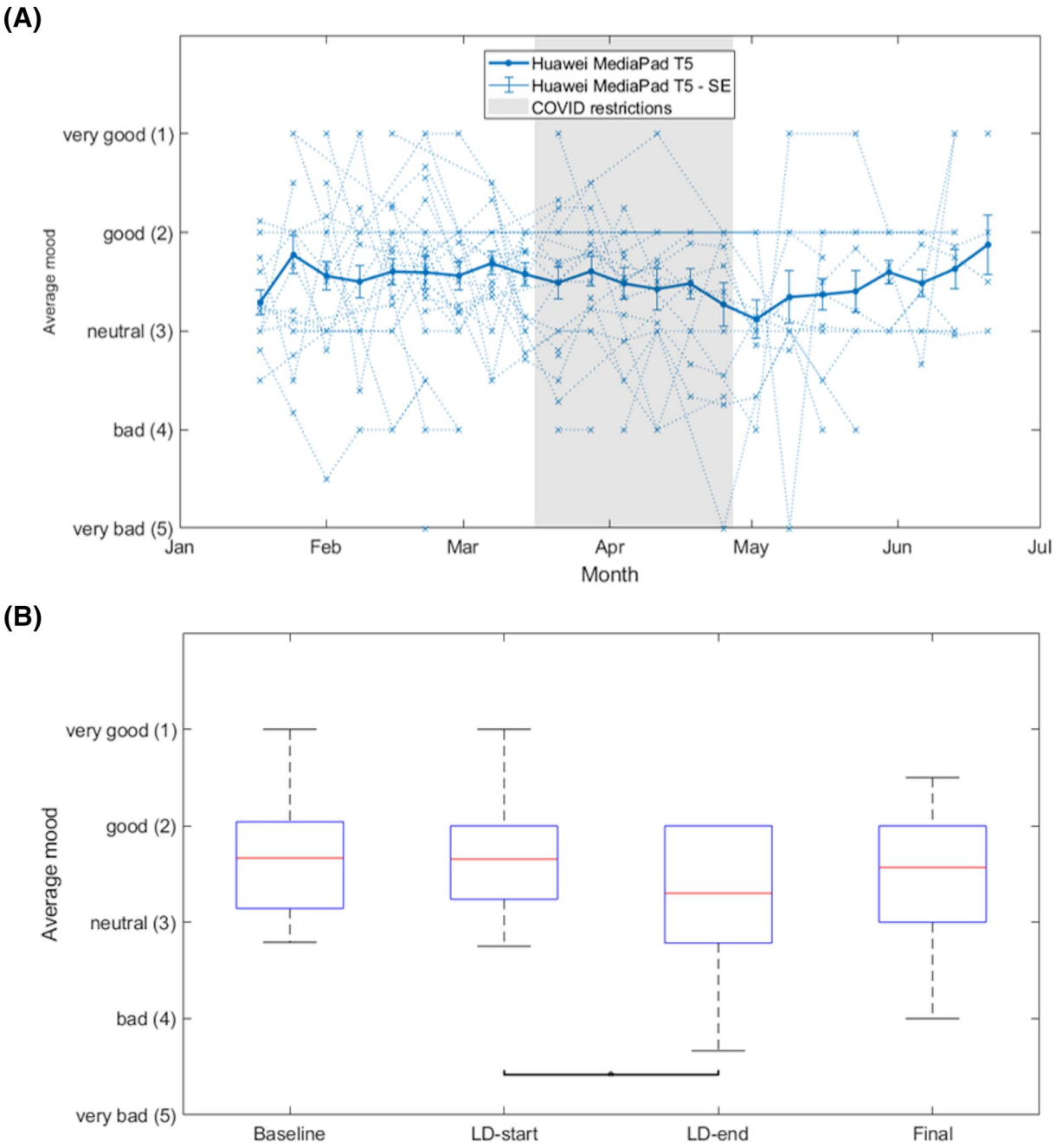

FIGURE 4 Average subjective mood data. (A) Subjective mood data per participant (dashed blue lines) plus average (including standard error) over all participants (blue line) and (B) corresponding Box plot for pre-specified timeframes. $^{*}p < 0.05$. SE, standard error

afterwards. This is an important insight and supports the theory that virtual contacts could make a complementary contribution to reducing social isolation in the older population.[6] Although the number of participants using the system had decreased during and after lockdown, the average number of Communication and Messages events per active user per week has increased. So, some users had increasingly used the DAPAS system, while others dropped the functionality. Furthermore, one can see a clear difference between the countries (see Figure 3B). This difference between AT and LU can most probably be attributed to the different measures that had been implemented to mitigate COVID-19. In LU, the participating older adults lived in their own flats, and the project leaders were not allowed to keep in touch with the participants; they had to stay away. In AT, some caregivers from geriatric facilities took over and supported the participants using the system during the lockdown. Especially, the Austrian user organisation started to motivate their participants to use the DAPAS system for communication activities to stay connected. Therefore, the increased number of events might be traced back to some users, who were well connected and motivated by their caregivers and relatives. Another important aspect is

that usage of other ways of communication, such as normal telephone use, services and apps for messaging or voice calls, was not recorded by the DAPAS system and is thus not known. Therefore, data in this study only refer to communication enabled by the DAPAS system.

Concerning the second research question, it was found that the self-reported mood dropped significantly during the lockdown and slightly increased thereafter again. The data show a similar trend as can be seen in the mobility data.[20] In their study about the impact of COVID-19 on psychological consequences, Li et al.[22] also showed that negative emotions increased, while the scores of positive emotions and life satisfaction decreased during the pandemic. In line with our data, De Pue et al.[23] just published data from an online survey showing the severe impact of the current pandemic on the mental health of older adults. One possible explanation for the improved mood among the participants in our study might have been the increased personal contact and better support of the participants in technical questions After-LD.

The need for support using ICT solutions is not only known from care but became evident in other areas as well. Examples from cardiovascular research summarise that COVID-19 has profoundly reshaped the usual care of both ambulatory and acute cardiac patients.[24] Like changes and shortcomings in the home care domain, elective procedures were cancelled, and the existing urgent care pathways were changed due to COVID-19.[24] Even in this highly medical domain, the need for ICT solutions for teleconsultations, -monitoring, and -management for high-risk patients or patients with chronic conditions is deemed necessary to overcome the current pandemic without long-term consequences.[25] The same applies to the area of nursing and care. Strutt et al. highlight the benefit of taking up communication technology during a lockdown as associations with better emotional health and quality of life were observed.[14] Innovative solutions, such as the DAPAS system, can support individuals and help care organisations to keep their standards. Importantly, systems need to be mature and validated, which is currently ongoing in the DAPAS project.

The strength of the current study is the comprehensive data analysis on the use of a new technology and the mood of older adults before, during and after COVID-19 lockdown. Regarding limitations, an important fact is that the system in use is still under development at an early prototype stage and not a fully mature product. Thus, some results might be due the immaturity of the system and thus generalizability is limited. Further research could explore the user experience and acceptability of the DAPAS system in more detail by also using qualitative research methods. The authors are also aware that the participants could have also used other means of communication, apps, calendar, and games, but not through the DAPAS system. Although the lockdown hampered the further roll-out of the DAPAS system in AT and LU, and the installation process could not start in Portugal, we could still analyse older adults' data on mood over a longer period. Unfortunately, the numbers of the participants were too small to allow for adequately powered sub-group analyses to compare between countries; data and trends stratified for sex and country are presented in the Supplementary Material.

In conclusion, this study provides information about the usage of the DAPAS system during COVID-19 lockdown. Furthermore, it gives insights in the impact of the lockdown and its slow release on the self-reported mood of older adults. Strategies and interventions are needed to support older adults who had started to use new ICTs for overcoming social isolation just before a lockdown. Otherwise, people might reduce or even stop using the new technology during prolonged periods of crisis.

ACKNOWLEDGEMENTS

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CONFLICT OF INTEREST

The authors declare no competing interests.

ETHICS APPROVAL

The study protocol was approved by the local ethics committees, the study adhered to the Declaration of Helsinki.

PATIENT CONSENT

All patients gave oral and written informed consent.

PERMISSION TO REPRODUCE MATERIAL FROM OTHER SOURCES

Policy response and mobility data are publicly available information.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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