Human-dog relationships during COVID-19 pandemic; booming dog adoption during social isolation

Liat Morgan^a, Alexandra Protopopova^b, Rune Isak Dupont Birkler^c, Beata Itin-Shwartz^d, Gila Abells Sutton^a, Alexandra Gamliel^a, Boris Yakobson^e, Tal Raz^{a*}

^aKoret School of Veterinary Medicine, Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel.

^bFaculty of Land and Food Systems, University of British Columbia, Vancouver, BC, Canada.

^cBLAVATNIK CENTER for Drug Discovery, Metabolite Medicine Division, Tel Aviv University, Tel Aviv, Israel.

^dEnvironmental Economics and Management, Robert H. Smith Faculty of Agriculture, Food and Environment, The Hebrew University of Jerusalem, Rehovot, Israel.

^eKimron Veterinary Institute, Ministry of Agriculture and Rural Development, Rishon Lezion, Israel.

*Corresponding author. tal.raz@mail.huji.ac.il

Abstract

The recent COVID-19 pandemic led to uncertainty and severe health and economic concerns. Previous studies indicated that owning a companion animal, such as a dog or a cat, has benefits for good mental health. Interactions with animals may help with depression, anxiety, and stress, in particular under stress-prone conditions. Companion animals provide companionship, improve mood, and may ease loneliness; human-animal interactions may even improve peer-to-peer social relationships, as well as enhance feelings such as respect, trust, and empathy between people. Interestingly, it has also been shown that stress and poor well-being of dog owners negatively affect the stress and well-being of their companion animals. Accordingly, we hypothesized that the COVID-19 pandemic, and the related social isolation, might lead to dramatic changes in human-dog bidirectional relationships. Using unique prospective and retrospective datasets, our objectives were to investigate how people perceived and acted during the COVID-19 pandemic social isolation, in regards to dog adoption and abandonment; and to examine the bidirectional relationships between dog owners' well-being to that of their dogs. Overall, according to our analysis, the stricter the social isolation became during the pandemic, the interest in dog adoption as well as adoption rate increased significantly, while abandonment did not change. Moreover, there was a clear association between individuals' impaired quality of life and their perceptions of poorer life quality of their dogs as well as the development of new behavioral problems. These findings suggest potential benefits for human-dog relationship during the COVID-19 pandemic, in compliance with the One Welfare approach.

Introduction

The virus SARS-CoV-2 emerged in December 2019, in Wuhan, China. This unknown respiratory disease developed into the pandemic, termed COVID-19, as declared by the World Health Organization on March 2020 (1). One of the main approaches worldwide for combating the disease is social isolation and distancing, at least as long as a protective vaccine is not available (2-4). Social isolation may prevent the spread of the disease, but it may also come with other concerns. One of the greatest concerns regarding the influence of social isolation is its psychological effect on humans. Extended social isolation may lead to a significant decrease in quality of life and well-being, and high levels of stress, also among the non-infected populations (4, 5). Social isolation is an additional stressor to an already highly stressful world environment and many people's extensive fear of the novel COVID-19 pandemic threat (4, 6, 7). In addition, social distancing included full lockdowns in many countries, as well as in Israel, with dramatic economic effects (8, 9). The adverse local and global economic impacts, on top of the drastic personal income reduction, may add another psychological aspect to the potential impairment of people's health and well-being (5).

Interestingly, the mental health benefits of owning a companion animal, such as a dog or a cat, have been shown by several scientific studies over the last years (10-12). The majority of studies point out that interactions with animals may help with depression, anxiety, and stress, in particular under stress-prone conditions (11). Companion animals provide companionship, improve mood, and may ease loneliness; human-animal interactions may even improve peer-to-peer social relationships, as well as enhance feelings such as respect, trust, and empathy between people (11-13). Paradoxically, it has also been shown that stress and poor well-being negatively affect the stress and well-being of their companion animals (14-16). For example, it was indicated that the stress of the owner could influence their dog's cognitive ability (15). Moreover, changes in the owners' attention to their dogs may affect the dogs' behavior (17, 18). Therefore, we hypothesized that the COVID-19 pandemic might lead to dramatic changes in human-dog bidirectional relationships. On the one hand, owning a dog may assist the owner in coping with the stressful world situation, and therefore, more people may decide to adopt a dog during this pandemic. On the other hand, behavioral problems in dogs were reported to be one of the main reasons for the abandonment of dogs to shelters (19, 20); if changes in the owners' lives occurred during the COVID-19 pandemic, and indeed if behavioral problems in their dogs developed as was shown under other circumstances(15), then, this may increase the risk for dog relinquishment.

Another potential risk factor for dog abandonment and relinquishment during the COVID-19 pandemic was their suspected epidemiological role in the spread of SARS-CoV-2. There was a worldwide growing concern that companion animals, specifically dogs and cats, can transmit the

disease to humans (21-23). Although the anecdotal reports were inconclusive, potentially, it could lead to an increase in the number of dogs relinquished by their owners. Thus, overall, the inconclusive reports of companion animals being potential carriers of the COVID-19 virus, the economic crisis, and the general stress and panic during this pandemic, could potentially cause a dramatic increase in dog abandonment numbers. Such a scenario may come along with high costs and considerable risk to public health, and therefore should have been explored. Relinquishment and abandonment of companion animals is a global problem; it is estimated that millions of pets are being abandoned each year (24), even without a pandemic in the background. It results in increasing numbers of free-roaming, overcrowded animal shelters, impaired animal welfare, and carries high costs to tax payers (24). Moreover, it is a severe public health issue due to the potential transmission of zoonotic diseases (such as rabies) and attacks of people (25, 26). All of these threats also carry remarkable economic consequences, which affect national and local governments, humane organizations, as well as individuals (25).

In 2012, an online, searchable database of animals that need homes in Israel was established (<http://Yad4.co.il>) by the first author, on a voluntary basis. The first and only project of its kind in Israel, Yad4, serves as a national database for dog adoption, as it includes the vast majority of abandoned dogs that need homes throughout the country. As such, the established database provides both an understanding of the current landscape of dog abandonment and adoption at any given moment, as well as a unique look into the longitudinal relationships of dogs and people as the same dogs may be tracked across time, multiple homes, and shelter visits. The Yad4 initiative aims to rescue the lives of abandoned animals in Israel by increasing adoption rates, reducing the extent of dog euthanasia, shortening the length of stay at the shelters until adoption, and has no profits purposes. The website offers a user-friendly search engine for potential adopters, with available dogs from organizations and municipal shelters across the country of Israel. The information is uploaded and updated by animal welfare organizations and municipal veterinarians, typically as soon as they have the dog in their possession. As of 2020, 72 animal welfare organizations and municipal shelters are registered and active on the website, each managing its own pool of adoptable pets independently, with its own online account. During the COVID-19 pandemic, the website was operated as usual; however, initially, there was a concern for massive abandonment and a decrease in adoption.

In order to control the pandemic, gradual social restrictions initiated during March 2020 in Israel, while in April, a total lockdown was implemented for a full month by the Israeli government, as marked on the timeline in Fig. 1. During this period, walking the dog and veterinary care were exceptions for the lockdown restrictions, as well as dog adoptions from animal welfare organizations and municipal shelters. Therefore, while it was not allowed to be outside of a 100 m radius from your house, dog adoption and dog walking were always permitted throughout these periods.

According to the mentioned above, the objectives of this study were: (1) to investigate how COVID-19 pandemic affected adoption and abandonment of dogs into shelters, and the public's general interest in adopting a dog; (2) to examine the correspondence between the owners' and their dogs' quality of life during the pandemic, as well as (3) its effect on the recognition of new behavioral problems and relinquishment rate of dogs by their owners.

Figure 1

Timeline of COVID-19 pandemic in Israel

The different colors, which get darker, represent the various periods analyzed in this study (x-axis): before the COVID-19 outbreak in China (years 2016-2019; light grey); from the initial outbreak in China until the first diagnosed patient in Israel (dark grey); during the outbreak in Israel, from the diagnosis of the first COVID-19 patient until lockdown declared by the Israeli government (light brown); during the full lockdown for a month (brown); and the gradual opening on May (grey, on the right side of the figure). The daily number of new diagnosed COVID-19 patients in Israel is represented as red dots.

Results

The current study focused on a new aspect of the COVID-19 pandemic by investigating the human-dog relationship under this crisis. Dog adoptions, abandonment, as well as the correspondence between the well-being of the owners and their perceptions of their dogs' quality of life, were examined. Overall, in contrast to some of the initial concerns, all dog adoption measures significantly improved as the social restrictions became stricter. Furthermore, there was a clear association between individuals' quality of life and their perceptions of their dog quality of life and behavior, as well as the probability of relinquishing it.

Changes in dog adoption and abandonment

The database of Yad4 website was analyzed in order to investigate dog abandonment and adoptions under the growing pressure of the COVID-19 pandemic. Most abandoned dogs which are offered for adoption in Israel are published on Yad4 website, which includes most animal welfare organizations and municipal shelters for dogs. Therefore, the dogs uploaded on a daily basis to the website represent the abandoned dog population, which includes mainly dogs that were relinquished by their owners. Overall, according to our analysis, the stricter the social restrictions became during the COVID-19 pandemic in Israel, the number of potential adopters (people looking to adopt a dog), as well as dog adoption rate, increased significantly (Fig. 2); while dog abandonment did not change. Multiple Linear Regression analyses of Yad4 records from January 2016 to May 2020 revealed that the main periods during the development of the pandemic in Israel were significantly associated with influence on dog adoption measures, while the abandonment rate did not change (Fig. 2; Supplementary Table 1). The number of dogs uploaded to the website, which represents most of the abandoned dogs in Israel, did not change significantly over the years, including during the COVID-19 pandemic (Fig. 2a-c). On the contrary, adoption measures were significantly affected by the different periods (Fig. 2d-i), particularly after the first COVID-19 patient in Israel was diagnosed, and even to a further extent during the social lockdown. Between the time that the first patient in Israel was diagnosed to the full lockdown of the country, the average number of adoption requests submitted online was 31.1 ± 1.9 (Mean $\pm$ SEM) requests per day, during the total lockdown, the average number of dog adoption requests was 111.3 ± 4.1 requests per day, and during the gradual opening on May 73 ± 4.6 adoption requests were submitted per day. However, before the COVID-19 outbreak in China, the average number of dog adoption requests was only 25.7 ± 4.1 requests per day. The Linear Regression analysis revealed that after controlling the effects of the month, the year and governmental initiatives for the encouragement of responsible dog ownership between 2018 to 2019, the increase in the number of adoption requests during the outbreak in Israel, and the full lockdown, were significantly higher as compared to the period before the COVID-19 outbreak in China ($P < 0.05$; Fig. 2d-f; Supplementary Table 1). Accordingly, the average number of adopted dogs increased significantly already after the outbreak in China, as well as during the outbreak in Israel and the full lockdown, as compared to before the pandemic ($P < 0.05$; Fig. 2g-i; Supplementary Table 1). After the outbreak in China, the average daily number of adopted dogs was 17.3 ± 2.2 dogs per day, during the outbreak in Israel it was 22.8 ± 2.1 adopted dogs per day, during the total lockdown it was 26.1 ± 2.2 adopted dogs per day, and after the gradual opening it was 14.7 ± 1.1 , which is similar to the period before the COVID outbreak in China (14.1 ± 0.3 adopted dogs per day). Furthermore, as compared to the years prior to the COVID-19 pandemic, the length of stay (LOS) of the dog at the shelter, calculated by the interval from the time the dog was uploaded online to Yad4 website until it was

marked by the organizations as adopted, was significantly shorter following the media reported about the COVID-19 outbreak in China and after (with the shortest LOS of 10.1 ± 0.5 days during the full lockdown). Potential effects such as the month, the year, and governmental initiatives were controlled in the Linear Regression models (Supplementary Fig. 1; Supplementary Table 1; $P < 0.05$).

Figure 2

Dogs adoption and abandonment measures, during COVID-19 outbreak in Israel

Each row represents data of a different variable: upper row (panels a-c)- number of abandoned dogs (marked in red); middle row (panels d-f)- number of adoption requests made by potential owners (marked in blue); lower row (panels g-i)- number of adopted dogs (marked in green). Daily data is presented on the first and second columns. Each dot represents the daily number of each parameter, to demonstrate trends over time. In the left column (panels a,d,g), data are presented from 2016 until May 2020. On the middle column (panels b,e,h) data are presented as zoom-in, from November 2019 to May 2020. Period of times related to the COVID-19 pandemic are separated by colors, as detailed in Fig. 1. In the right column (panels c,f,i), the results of Multivariate Linear Regression models are presented. In these models, the predictors were: the different time periods, from the outbreak in China to outbreak in Israel, the developments in Israel until full lockdown, full lockdown, and gradual opening; each period was compared to the period prior to COVID-19 pandemic (from 2016 until the outbreak in China, represented by the horizontal dotted line); controlled for year, month, and governmental initiatives for dog adoption on 2019. The data are presented as coefficients (large dots) and its 95% confidence interval (bars); $P < 0.05$.

Another option available for the public on Yad4 website was to fill a request to serve as a foster family, as an alternative to adoption. Usually, the demand for foster families among the organizations is very high, but the number of available foster families is low. Therefore, typically, there are no available foster families that the organizations do not use. During the pandemic period, the number of foster families was higher than the demand. Accordingly, from the reports about the outbreak in China until the end of the lockdown in Israel, as well as during the gradual opening, the number of available foster families increased significantly. For example, as described in Fig. 3a-b, by the end of April 2019 there were no available foster families on Yad4 website, since they were all occupied and used by the organizations; contrarily, at the time of the outbreak in China, 226 foster families were available but did not receive a dog to foster, and by the end of April 2020, there were 844 available foster families.

Local and global online searches for adoptable dogs

The daily number of visitors on Yad4 website since the first diagnosed COVID-19 patient in Israel until the end of the full lockdown was significantly higher, as compared to the whole period before the pandemic (Fig. 3). The effect of year and month were controlled in the models (Sup Table 1). Linear Regression model revealed that there was a significant increase in daily visits online when the outbreak emerged in Israel during March by 657.9 ± 80.8 (coefficient $\pm$ SE) visits, and by $2,311 \pm 82.1$ daily visitors online during the total lockdown period (Fig. 3a-c; $P < 0.05$). For example, the absolute number of visits online in April 2020 was 221,959 visits, as compared to 72,703 in April 2019, and 91,920 visits in October 2019, which is typically the busiest season of the website. Interestingly, according to global non-scientific media reports, the demand for adoptable dogs worldwide was also high in other countries. Pictures of empty cages from many countries were published, but until now, to the best of the authors' knowledge, no scientific data has yet been published. Thus, the global trend was investigated by analyzing Google Trends data for searches all around the world, as well as specifically in the USA. In order to do so, the timeline was divided to three periods: (1) before the outbreak in China; (2) from the media reports about the outbreak in China on December 27th until March 13th - when the World Health Organization (WHO) announcement of Europe as the epicenter of the pandemic; (2) the main lockdown worldwide - from the announcement of the WHO until the gradual opening on May; and (4) during May. The effect of year and month were controlled in the models (Supplementary Table 2). Interestingly, the world trends, according to the Google Trends data, were found to be similar to that we report herein for Israel (Fig. 3). The trends of worldwide searches online for "adopt a dog" were significantly higher during the periods of the outbreak in China, as well as during the period many countries declared lockdowns, as compared to the year of 2019 (Fig. 3d-f).

Figure 3

Online users' visits in the Israeli Yad4 website, and worldwide Google searches, for adoptable dogs before and during COVID-19 pandemic

(a) The daily numbers of visitors on Yad4.co.il, the Israeli adoption search engine, from January 2016 to May 2020. (b) Zoom-in on the same data as in panel a during COVID-19 pandemic, from November 2019 to May 2020. (c) Results of the Linear Regressions model for Yad4 online visits, in each period during the COVID-19 pandemic, as compared to before the pandemic. In these model, the predictors were: the different periods, from the outbreak in China to outbreak in Israel, the developments in Israel until full lockdown, full lockdown, and gradual opening; each period was compared to the period prior to the COVID-19 pandemic (from 2016 until the outbreak in China, represented by the horizontal dotted line); controlled for: year, month, and governmental initiatives for dog adoption on 2019. (d) The weekly trends of Google searches for “adopt a dog” are presented from November 2019. (e) Zoom-in on the same data as in panel d, during COVID-19 pandemic. Both worldwide searches (orange) and USA searches (blue) are presented. (f) Results of the Linear Regressions model for global searches for adoptable dogs. In this model, the predictors were: the different periods, from the outbreak in China to the declaration of the World Health Organization on Europe as the epicenter of the pandemic, during the time most of the world was under restricted social isolation, and the gradual opening on May 2020. Each period was compared to the period from January 2019 to the outbreak in China (represented by the horizontal dotted line); controlled for: year and month. In panels c and f, data are presented as coefficients (large dots) and its 95% confidence interval (bars); $P < 0.05$.

Given the discovered high demand for dogs to adopt during the pandemic, the second part of our study included questionnaires targeting people who adopted a dog, as well as to current dog owners, to explore the motivation behind this increase in demand for adoptable dogs.

The motivation for dog adoptions during COVID-19 pandemic lockdown, and the return rate of dogs back to shelters after the gradual opening

An online questionnaire was carried out in order to explore reasons for dog adoption, particularly during the COVID-19 related lockdown, as well as to explore the return rate of the adopted dogs to the shelters, during the lockdown, and after opening. This questionnaire was active for five days, starting on May 20th, 2020 (20 days after the gradual opening of the lockdown), and targeted people who adopted a dog from a shelter during the COVID-19 pandemic. The questionnaire targeted individuals who adopted a dog as described in Methods, with the resulting n=508 people in total; 312 of respondents stated they adopted during the pandemic (January-May). Of these 312 adopters, 38.5% participants stated they have considered adopting a dog for a long time, and being at home during the COVID-19 lockdown seemed like a good opportunity; 37.8% stated they planned to adopt a dog regardless the situation; 8.0% stated they felt lonely and/or stressed and believed that owning a dog might help; 9.3% heard about dog abandonment in the media and felt it was the right thing to do; and fewer people adopted for other reasons, as detailed in Fig. 4. Only 8 out of the participants who adopted during the pandemic (2.6%) already returned or relinquished the dog or have been considering relinquishment.

Fig 4

Reasons for dog adoption during the COVID-19 pandemic

The frequencies of the participants' statements for the reason to adopt specifically during the pandemic are presented. Reasons related to the pandemic are marked in red. Other reasons are presented in black.

The association between owners' impaired quality of life to their perception of their dogs' quality of life

In order to study the correspondence between the quality of life of owners and their companion dogs under the COVID-19 pandemic circumstances, a digital questionnaire for dog owners was active during the full lockdown and social isolation (April). Participants replied to questions regarding their own well-being, as well as the well-being of their companion dog. Questions

such as the effect of the pandemic on their stress level, personal economic damage, their concern about their own health, and their perceptions regarding their dog well-being and behavior under the COVID-19 related lockdown, were included. The questionnaire also included background questions about the owners and their dogs, as well as the care they provided to their dog during the pandemic, that were controlled in the models (details in Supplementary Table 3). The questionnaire was answered by $n = 3,138$ individuals; and the outcome variables answers were set on a scale of 1-5 (for example, 1- low stress; 5- extremely stressed). Scores 4 and 5 were relabeled as “severe stress” for the analyses, and they were compared to scores 1-3: “none to moderate”. Overall, 25% of the participants were very concerned about their health (Fig. 5a), 25.6% stated they were extremely stressed (Fig. 5b), and 22.9% reported that their personal economy was severely damaged (Fig. 5c). For further analysis, impaired quality of life index was calculated as the mean of these scores (general stress; concern for their own health; and the damage to their personal economy; Fig. 5d). In addition, in the questionnaire, owners were asked to rank on a scale of 1-5 their assessment for their dogs’ quality of life during the COVID-19 lockdown, as well as their recognition of new behavioral problems, and whether they consider relinquishing their dog.

As hypothesized, Multiple Multivariate Logistic Regressions revealed that an increase in the impaired quality of life index of the owner was associated with lower life quality of the dog, as was assessed by the owner (odds ratio: 0.887 times lower for every one-unit increase in owner's quality of life index; Fig. 5e; $P < 0.05$). In addition, for a one-unit increase in impaired quality of life index of the owner, the odds ratio for recognition of new behavioral problems of the dog (as defined and recognized by the owner) was 1.397 times higher (Fig. 5e; $P < 0.05$). Moreover, for a one-unit increase in the impaired quality of life index of the owner, the odds ratio for relinquishment was 1.762 times higher (Fig. 5d; $P < 0.05$). Overall, the number of people that recognized behavioral problems among their dogs was low (11.6% of the dog owners), as well as the number of people that intend to relinquish their dog (1%). Still, according to these data, severely impaired quality of life of owners under the COVID-19 pandemic and lockdown was a significant risk factor to the dog's life quality, as well as for the recognition of dog's behavioral problems, and dog relinquishment, as reported by dog owners. Parameters of dogs' and owners' backgrounds, as well as ownership habits, were controlled in the statistical models, as fully detailed in the Material and Methods and Supplementary Table 3. Further questions that were included in the model, regarding the type of behavioral changes in the dogs are presented in Supplementary Table 4.

Figure 5

Association between dog owners' life-quality and their perceptions of their dog's life-quality and behavior

(a) Frequencies of participants' answers regarding their concern for their own health on a scale of 1-5. (b) Frequencies of participants' answers regarding their stress level on a scale of 1-5. (c) Frequencies of participants' answers regarding their personal economic damage on a scale of 1-5. (d) Index of the impaired quality of life of the owner, based on the data presented in panels a-c. (e) Results of Logistic Regression model for dog's parameters by the increased impaired quality of life of the owners, as reported by the owner; dog life quality (round dot), development of dog behavioral problems (square), and the owner's intention to abandon the dog (triangular). Data are presented as odds ratios and its 95% confidence interval (bars); $P < 0.05$ when the 95% confidence interval does not cross the horizontal dotted line.

Discussion

Humans and dogs are both social animals, and their bond can be traced back at least 15,000 years ago to the Bonn-Oberkassel dog that was found buried with two humans (27). According to the 2019-2020 National Pet Owners Survey conducted by the American Pet Products Association (APPA), approximately 63.4 million households in the USA owned at least one dog, making them the most widely owned type of companion animal across the USA at this time. The advantages of raising a dog have been widely investigated. The human-dog bond potentially has physical, psychological and mental benefits, and can improve the general well-being and happiness of owners

(28-31). Despite all the known advantages, and the evidence that separation of a dog and its owner has negative impacts not only on the dog but also the wellness of the owner (32), millions of companion dogs are abandoned every year (33). Dog abandonment carries high costs and a significant risk for public health (24, 25, 34). Prior to this study, it was unknown whether the COVID-19 pandemic was a risk factor for dog abandonment, as well as a risk for impaired well-being of the dogs as a reflection for the potential impaired well-being of the owners. Therefore, the motivation to conduct the current study was to explore the human-dog relationship during this pandemic, to benefit the welfare and well-being of both humans and animals, in accordance with the One Welfare approach. The One Welfare approach extends the One Health theme, suggesting that there is a strong connection between welfare and health of human and animals (35-40). The rationale behind the current study was the hypotheses that human perceptions and acts regarding dog ownership and adoption might be influenced by the COVID-19 pandemic and the related social isolation, as well as the stress and well-being of both species.

Our data indicated that not only is the concern of increased dog abandonment not justified, at least so far, the opposite has occurred. The more social restrictions there were and the harder it got during the COVID-19 pandemic, measures of dog adoptions improved significantly (Fig. 2); the demand for adoptable dogs and to serve as a foster family increased significantly, and accordingly, the length of stay of dogs at the shelter was significantly shorter. Previous reports after disasters, such as earthquakes or other situations that require immediate evacuation, were associated with a massive unintentional dog abandonment (41). However, people may refuse to separate from their pet when needed due to disasters or extreme situations, as pet owners may find their pets closer or at least as close as family (30, 42). This may be the reason why, so far, the vast majority of people reluctant to relinquish their dog during the COVID-19 pandemic. Still, further investigations are required, as the potential risk for dog relinquishment in the coming months, due to the different social and economic impacts of this pandemic, cannot be completely excluded. Furthermore, as our climate continues to change, more disasters including pandemics will likely occur, highlighting the need for more research into crisis-driven human behavior change, including changes to the human-animal relationship.

While it may be clearer why people kept their companion animals, the motivation to acquire a new dog through adoption, particularly during the COVID-19 related lockdown, is less intuitive. As expected, many people stated they decided to adopt a dog since they have been planning to adopt before the COVID-19 outbreak, as well as the fact that people were at home and more available to the new challenge. In addition, acknowledgment of the fact that a dog can reduce feelings of stress and loneliness as well as misleading media publications about increased dog abandonment, played an important role in their decision. Surprisingly, neither the pressure from children and the desire to keep children occupied, nor an excuse to leave the house during the lockdown, were reported to play an

important role in the owners' decision to adopt a dog under the circumstances. In the scientific literature, the characteristics of individuals associated with a higher likelihood to adopt a dog, such as ethnicity and housing, were described (43, 44); however, the specific timing for adoption has not been investigated. Nevertheless, a previous study found that owners who just obtained a dog expected that the new dog ownership would increase their walking activity, happiness, companionship, and would decrease stress and loneliness (13). This may explain the increase in adoption rate during the COVID-19 pandemic, as social isolation was forced.

In addition, to determining the adoption and relinquishment rates associated with COVID-19, we investigated the effect of a stressful pandemic on dog welfare in the pet home environment. Therefore, the questionnaire for dog owners examined the relationship between their impaired quality of life during the pandemic and the quality of life of their companion dog. Although there is an explicit limitation in the current study that the life quality of the dog and the development of new behavior problems were assessed by the owner's perception and not objectively, the results are nevertheless valuable; as the perceptions of the owners of their dog's behavior is likely a more important predictor of relinquishment than objective measures. Previous research have found that new owners of dogs often do not report the same behavioral problems as relinquishing owners of the same dog, suggesting that perception plays an important role (45, 46).

It was found that impaired quality of life of the owners was associated with a decreased life quality of their dog, as well as increased development of new behavioral problems, as judged by their owners. Although it has been reported that owners have a poor ability to recognize behavioral problems (13, 47), the perception of the owners can influence the future of the owner-pet relationship, as well as the chances they would decide to relinquish it (48). Thus, the perception of the owner that their dog has behavioral problems may influence their ownership, and by that, also its welfare. As mentioned, the quality of life of the dog, and more than that, its behavior, were neither diagnosed objectively, nor by professional observers. Therefore, the background of the dogs and the owners as risk factors for the low quality of life and new behavioral problems of the dog, cannot be thoroughly concluded from these models. Still, those variables were controlled in the statistical models, and it was found that the perception of dog owners regarding their impaired quality of life was significantly associated with their assessment of the lower quality of their dog's life and its emerging behavioral problems. These results are consistent with previous studies, which found that there is an effect of humans' stress level and well-being on the stress, well-being, cognitive ability and behavior of their dogs (14, 15, 17). An alternative hypothesis may be that owners in a crisis situation may have had a pessimistic outlook regarding things in their life and their surroundings, and the resulting decrease of the dog's quality of life was due to the overall negative outlook of the owner rather than any true reflection of the dog. This information is important for both humans and dogs, since it can provide

valuable information for initiatives to improve the welfare and well-being of both the dog owners and their companion dogs, as suggested by the One Welfare approach. For example, the Israeli Veterinary Services (a branch of the Ministry of Agriculture), who invests an annual amount of approximately 1.2M \$ in encouraging responsible dog ownership and adoptions, already improved new upcoming initiatives based on the current study, such as digital online adoption days, with education regarding dog responsible ownership.

In this study, although the overall number of dog owners who reported that they were going to relinquish their dog due to the COVID-19 situation was low, it was significantly associated with a poorer quality of life index of the owners. Among dog adopters that adopted the dog during the pandemic, a similar percentage is reported for owners that already relinquished their dog or have been considering it. Since a lack of time of the owners is one of the main risk factors for dog relinquishment reported in the literature (20), it was a concern that people who adopted during the COVID-19 lockdown would relinquish their dog after going back to routine life. The second survey to detect the relinquishment rate of dogs adopted during the pandemic was performed at the end of May 2020, after opening the lockdown. Therefore, in most cases, it has been more than a month from adoption, to when people were back to routine life. According to previous research, the highest proportion of dog relinquishment happens just one month after adoption; in fact, owners report knowing of their dog's behavioral problem within 24 hours post-adoption (49). It is important to mention that people who decided to relinquish their dog might have avoided our survey. Still, the relatively low number of dogs that were uploaded to Yad4 website on May 2020 may indicate that, so far, there was not a massive relinquishment after opening the lockdown. Hence, we can carefully suggest that the majority of the adoptions were successful. One hypothesis can be that owners had more time to spend with their dog at the beginning, which may have helped to ease rehoming. Nonetheless, this hypothesis requires further investigation in the long run. Furthermore, an important issue that was not covered in the current research is related to the differences between individuals who already owned a dog to those who did not, in regards to their coping with the extreme social and economic challenges during the COVID-19 pandemic. Still, studies show that both children and adults cope better with stress when owning a dog (12, 42). Therefore, we hypothesize that owning a dog might even prevent the development of Post Traumatic Syndrome Disorders (PTSD) due to the pandemic or at least ease the coping with it, if it occurred. It has been reported that after the SARS outbreak in 2003, which may be equivalent to the COVID-19 pandemic in many aspects, patients suffered from Post Traumatic Syndrome Disorders (PTSD) (50). It is known that dogs have a positive effect on the treatment of PTSD, as well as that dog owners might be more resilient (12, 42, 51). Therefore, this is an important future direction to the human-pet relationship research.

In summary, the COVID-19 pandemic that emerged in December 2019 in Wuhan, China, led to the utilization of social insulation in many countries, as well as to public uncertainty and severe health and economic concerns. Our study indicates that the stricter the social isolation became during the COVID-19 pandemic, the interest in dog adoption and adoption rate increased significantly, while dog abandonment did not change. Furthermore, there was a clear association between individuals' quality of life and their perceptions of their dog quality of life and behavior, as well as the probability of relinquishing it. As humans and dogs are both social animals, these findings suggest potential benefits of the human-dog relationships during the COVID-19 pandemic, in accordance with the One Welfare approach implying that there is a bidirectional connection between the welfare and health of human and non-human animals.

Methods

The study was conducted according to the ethical guidelines of the Hebrew University of Jerusalem. As detailed below, data analyzed included four main datasets: (1) retrospective data from the pets adoption website Yad4 (<http://Yad4.co.il>), which is an online search engine for adoptable pets in Israel, for the period from January 2016 to May 2020; (2) retrospective data regarding worldwide Google searches for adoptable dogs were downloaded from Google Trends, for the period from November 2016 to May 2020; (3) data gathered in a prospective online digital questionnaire targeting dogs owners in Israel, which was active from March 27th, 2020 to April 30th, 2020, during the COVID-19 related full lockdown in Israel; and (4) data gathered in an online digital questionnaire targeted people in Israel who adopted a dog from a shelter during the COVID-19 pandemic, which was active from May 20th to May 25th, 2020, after the gradual opening of the lockdown.

Collection of data regarding abandoned adoptable dogs, adoptions and adopters from Yad4 website

Information regarding abandoned adoptable dogs, adoptions, and adopter's data were recorded by Yad4 open-source online website. In this Israeli website, animal welfare organizations and municipal veterinarians upload individual information for each abandoned dog, typically as soon as it enters the shelter, and this information is available to potential adopters who can fill an online adoption request through the website to be considered and approved by the shelter. Dataset included: records of the dogs uploaded to the website, date of marking the dog as adopted if indeed adopted, the number of adoption requests sent through the website, as well as requests to serve as foster families. Data regarding the online use of Yad4 website were extracted from Google Analytics. The database of the Yad4 website was analyzed from January 2016 to May 2020, and included: 33,883

adoptable dogs, 2,618,190 online visits on the website, 53,923 online adoption requests, and 2,042 fostering applications. As demonstrated in Fig. 1, data were compared in five different periods: from January 2016 until the outbreak in China; from the initial outbreak in China until the first diagnosed COVID-19 patient in Israel; during the outbreak in Israel, from the diagnosis of the first patient until the full lockdown declared by the Israeli government; during the full lockdown for a month; and the gradual opening on May 2020.

Collection of data regarding worldwide Google searches for adoptable dogs

Data regarding the use of the website and worldwide google searches for adoptable dogs were extracted by Google Analytics (<https://analytics.google.com>). Retrospective data (from January 2016 until May 2020) regarding trends of searches online for “adopt a dog”, both in the USA and worldwide, were downloaded from Google Trends (<https://trends.google.com>) and used for the analysis. As detailed below, data were compared in four different periods: before the COVID-19 outbreak in China; from the media reports about the outbreak in China on December 27th, 2020 until March 13th, 2020 – when the World Health Organization (WHO) announced Europe as the epicenter of the pandemic; from the WHO announcement until the gradual opening on May (the main lockdown in many countries worldwide); and (4) during May 2020 (gradual opening in many countries).

Online digital questionnaire for dog owners during the COVID-19 related lockdown in Israel

An online digital questionnaire targeting dog owners in Israel was active during the COVID-19 related full lockdown in Israel. The questionnaire was designed by the researchers using Google Forms, and was distributed by a company who specializes in this purpose (Lead Marketing Ltd.; <https://leadmarketingltd.com>), in order to specifically and effectively reach dog owners in Israel. The online distribution of the questionnaire was based on targeting a pre-defined group of respondents, with a high level of accuracy, characterized by their interests and online behavior (e.g., users that shop online for dogs’ food, searching for information on dog care). Various digital platforms were used (i.e., Google Display Network, Facebook, Instagram, and others), and banners ads led users to the questionnaire, asking them to voluntarily and anonymously participate in the survey with their consent to be part of this research.

The questionnaire for dog owners was in Hebrew, and participants were asked to reply to questions regarding their own well-being, as well as the well-being of their companion dog. It included questions regarding the background of the dog; source of their dog (e.g., adopted from a shelter, backyard breeding, official breeders), the age of the dog, reproductive status (sterilized or intact), the number of years they own the dog, where the dog is kept (e.g., inside an apartment, in a private house, in a garden, free roam). Background about the owners included age, the geographical

area in Israel, type of residential area (e.g., city, countryside), and gender. In addition, owners were asked questions regarding their well-being under the lockdown due to the COVID-19 pandemic (on a scale of 1-5); “how stressed are you overall from the COVID-19 pandemic?” (1- not stressed, 5- severely stressed); “to what extent are you worried about your health risk from the COVID-19 epidemic?” (1- not worried, 5- extremely worried); “to what extent the current crisis was harmful to your personal economic income?” (1- not at all, 5- severely harmful); “to what extent was your daily routine change during this time?” (1- no change, 5- extreme change). In addition, owners were asked how many times a day they walk the dog during the lockdown, the average length of the walk, whether the attention they gave the dog changed (increased, was not changed, or decreased), their assessment of their dog overall quality of life under the lockdown (1- remarkably impaired, 5 - remarkably improved), if there were new behavioral changes in their dog, and whether or not they are considering to relinquish their dog. For purpose analyses regarding the link between human well-being to their answers regarding their dog, an impaired quality of life index was generated, by calculating the average score of the owners based on the responses regarding their overall stress, health concerns, and their personal economic damage due to the COVID-19 epidemic and lockdown, as detailed above. The questionnaire was conducted between March 27th to April 30th, 2020, during the COVID-19 related full lockdown in Israel, and was successfully answered by 3138 individuals. Records that were not full, replied by people who stated they did not own a dog at the time of the questionnaire, minors (under 18 years old), and individuals who marked the age of the dog and the years they raise him by irrational number (e.g., 51, 139) were not included. Thus, 2,906 records were included in the analyses. Characteristics of the participants and their dogs are detailed in Supplementary Fig. 2.

Online digital questionnaire for people in Israel who adopted a dog from a shelter during the COVID-19 pandemic

An online digital questionnaire targeting mainly people in Israel who adopted a dog from a shelter during the COVID-19 pandemic, was active from May 20th to May 25th, 2020, after the gradual opening of the lockdown. The questionnaire was designed by the researchers in Hebrew using Google Forms, and was distributed by Lead Marketing Ltd., in a similar manner as the first questionnaire, in order to effectively target individuals of the pre-defined group, such as individuals who visited dog adoption websites, mainly Yad4, dogs shelters and their Facebook fan pages. Participants were asked to reply to questions regarding the date of dog adoption, the main reason for the specific timing of the adoption (Fig. 5), as well as on the short-term success of the rehoming (e.g., keeping the dog, gave it to another family, returned it to the shelter, or considering not to keep it). The questionnaire was answered by 508 participants, and 312 of them stated they adopted during the pandemic (January-May, 2020)

Statistical Analyses

Statistical analyses were performed using commercial statistical software (IBM SPSS Statistics, version 24.0; STATA, version 15.0). Linear Regression analysis was utilized to evaluate the effects of the spreading of COVID-19 and lockdown stages on adoption and abandonment outcomes for pet dogs, using data from the Yad4 adoption website. The general structure of the estimated regressions was as detailed in equation (1).

$$(1) Y_t = \beta_0 + \delta_{ChinaOutbreak} + \delta_{LocalOutbreak} + \delta_{LocalLockdown} + \delta_{OpenUp} + \gamma_t + \beta_1 \cdot trend_t + \beta_2 \cdot regulation_t + \varepsilon_t$$

Where Y_t was the outcome of interest in month t , the δ 's were dummy variable effects of the stages of outbreak and lockdown, all compared to the baseline period, before the outbreak of COVID-19 in China. $\delta_{ChinaOutbreak}$ is a dummy variable for the months between the outbreak of COVID-19 in China and the first confirmed case in Israel; $\delta_{LocalOutbreak}$ is a dummy variable for the period between the first local case and the start of the full lockdown; $\delta_{LocalLockdown}$ – between the start of the lockdown and the start of gradual opening in Israel. γ_t are calendar month fixed effects controlling for seasonality in adoption activities, and $trend_t$ controls for a linear annual time trend. $regulation_t$ controls for a change in governmental initiatives with regard to encouragement of responsible ownership and adoptions between 2018 and 2019, to make sure this does not drive our results. ε_t is a standard error term. Several outcomes were considered variables: the number of adoption requests received through the website and the number of dogs marked as adopted, as measures of the level of interest in conducting an adoption process and the final outcome of successful adoptions; the number of uploaded dogs, as a measure of recent abandonment cases; the number of users on the website, as a measure of general interest in adoption.

The major part of the analysis uses Israeli data, as detailed above. However, two outcome variables were added from Google Trends to compare the results to worldwide trends. Google Trends were used to construct two additional outcome variables: the number of web-searches, in the US, and worldwide, of the phrase "adopt a dog" during the same period. The regression analysis for these outcomes was similar to the main model, but the stages of shutdown were defined as: the outbreak in China, the declaration of World Health Organization on Europe as the epicenter of the pandemic, and the gradual opening in May 2020. Because the lockdown policies are not centralized in the US and worldwide, we did not include a specific separate shutdown time-period.

The dog owners' digital questionnaire was analyzed using a Logistic Regression. The binary outcome variables that were considered are: the life quality of the dog, as assessed by the owner; the development of new behavioral problems if recognized and defined by the owners; and whether the owner was considering abandoning the dog. The general model for estimation was as detailed in equation 2.

$$(2) \text{Prob}(Y_i = 1) = \beta_0 + \beta_1 \cdot \text{LifeChange}_i + \beta_2 \cdot \text{CrisisIndex}_i + \gamma \cdot Z_i + \delta \cdot W_i + \alpha \cdot D_i + v_i + \varepsilon_i$$

Where Y_i is the binary outcome of interest for respondent i . LifeChange_i is a dummy variable depicting whether the respondent declared that his life changed following the COVID-19 outbreak. CrisisIndex_i is an average of three responses addressing three aspects of negative effects of the outbreak: economy, health concern, and stress (as reported by the responders). Z_i are owner characteristics: gender, age and whether there are young kids in the household. W_i are dog characteristics: age, whether the dog was adopted from a shelter, number of years with the owner. D_i are characteristics of the care given to the dog: number of walks a day, the average duration of the walks, and a general measure of attention to the dog. v_i are geographical area fixed-effects and ε_i is a standard error term. The Logistic Regressions, as they are based on the responses of the owners, which can be biased on their own, should be interpreted as descriptive analysis rather than being given causal interpretation.

Descriptive statistics are given as Mean $\pm$ SE, 95% confidence interval, or as frequency (n) with percentage (%), as applicable. A $P < 0.05$ was considered statistically significant. All reported P-values were based on a two-tailed hypothesis.

Acknowledgments

We thank the Yad4 website for sharing their data, and specifically to Mr. Omri Amos, the technical developer of YAD4 for extracting the data, as well as the CTS group, and Farmina pet-food, Israel, the current supporters of the website. We thank all study participants and adopters who were willing to provide information. We thank the Universities Federation for Animal Welfare (UFAW) for their support in all our work regarding animal welfare in Israel. Gratitude to Ms. Odelya Natan and her team from Lead Marketing Ltd. The study was funded by the Israeli Ministry of Agriculture and Rural Development.

Author contributions

T.R. supervised the project, conceived ideas, and revised the manuscript. B.Y. co-supervisor of the project. L.M. conceived the ideas, conducted the study, analyzed the results, and wrote the manuscript. A.P. took part in the study design, ideas, and writing of the manuscript. R.B. assisted with the analyses and writing the manuscript. B.I.S. contributed with the ideas, design, conducted the statistical analyses and participated in writing the manuscript, G.S. contributed to the statistical analyses. A.G. collected data and revised the manuscript. All authors read, revised and approved the manuscript.

Competing Interests: Liat Morgan is the founder and the owner of Yad4 website. The ownership of the website had no influence on the objectivity and the integrity of the manuscript.

Supplementary information accompanies this paper, in a separate file.

References

- .1 E. Bojdani *et al.*, COVID-19 Pandemic: Impact on psychiatric care in the United States. *Psychiatry Res* **289**, 113069 (2020).
- .2 J. R. Koo *et al.*, Interventions to mitigate early spread of SARS-CoV-2 in Singapore: a modelling study. *Lancet Infect Dis* 10.1016/S1473-3099(20)30162-6 (2020).
- .3 J. A. Lewnard, N. C. Lo, Scientific and ethical basis for social-distancing interventions against COVID-19. *Lancet Infect Dis* 10.1016/S1473-3099(20)30190-0 (2020).
- .4 J. J. V. Bavel *et al.*, Using social and behavioural science to support COVID-19 pandemic response. *Nature Human Behaviour* **4**, 460-471 (2020).
- .5 H. Xiao, Y. Zhang, D. Kong, S. Li, N. Yang, Social Capital and Sleep Quality in Individuals Who Self-Isolated for 14 Days During the Coronavirus Disease 2019 (COVID-19) Outbreak in January 2020 in China. *Med Sci Monit* **26**, e923921 (2020).
- .6 J. LeDoux, Rethinking the emotional brain. *Neuron* **73**, 653-676 (2012).
- .7 D. Mobbs, C. C. Hagan, T. Dalgleish, B. Silston, C. Prevost, The ecology of human fear: survival optimization and the nervous system. *Front Neurosci* **9**, 55 (2015).
- .8 M. K. Anser *et al.*, Does communicable diseases (including COVID-19) may increase global poverty risk? A cloud on the horizon. *Environ Res* **187**, 109668 (2020).
- .9 S. Sangar, V. Dutt, R. Thakur, Comparative Assessment of Economic Burden of Disease in Relation to Out of Pocket Expenditure. *Front Public Health* **7**, 9 (2019).
- .10 J. Serpell, Beneficial effects of pet ownership on some aspects of human health and behaviour. *J R Soc Med* **84**, 717-720 (1991).
- .11 A. Beetz, K. Uvnas-Moberg, H. Julius, K. Kotrschal, Psychosocial and psychophysiological effects of human-animal interactions: the possible role of oxytocin. *Front Psychol* **3**, 234 (2012).
- .12 L. Powell *et al.*, Companion dog acquisition and mental well-being: a community-based three-arm controlled study. *BMC Public Health* **19**, 1428 (2019).
- .13 L. Powell *et al.*, Expectations for dog ownership: Perceived physical, mental and psychosocial health consequences among prospective adopters. *Plos One* **13** (2018).
- .14 A. P. Buttner, B. Thompson, R. Strasser, J. Santo, Evidence for a synchronization of hormonal states between humans and dogs during competition. *Physiology & Behavior* **147**, 54-62 (2015).
- .15 Z. Sumegi, K. Olah, J. Topal, Emotional contagion in dogs as measured by change in cognitive task performance. *Applied Animal Behaviour Science* **160**, 106-115 (2014).
- .16 M. G. Ryan, A. E. Storey, R. E. Anderson, C. J. Walsh, Physiological Indicators of Attachment in Domestic Dogs (*Canis familiaris*) and Their Owners in the Strange Situation Test. *Front Behav Neurosci* **13**, 162 (2019).
- .17 J. Kaminski, J. Brauer, J. Call, M. Tomasello, Domestic dogs are sensitive to a human's perspective. *Behaviour* **146**, 979-998 (2009).

- .18 E. Payne, J. DeAraugo, P. Bennett, P. McGreevy, Exploring the existence and potential underpinnings of dog-human and horse-human attachment bonds. *Behav Processes* **125**, 114-121 (2016).
- .19 G. J. Patronek, L. T. Glickman, A. M. Beck, G. P. McCabe, Risk factors for relinquishment of dogs to an animal shelter. *Journal of the American Veterinary Medical Association* **209**, 572-581 (1996).
- .20 M. D. Salman *et al.*, Behavioral Reasons for Relinquishment of Dogs and Cats to 12 Shelters. *Journal of Applied Animal Welfare Science* **3**, 93-106 (2000).
- .21 M. Goumenou ,D. A. Spandidos, A. Tsatsakis, [Editorial] Possibility of transmission through dogs being a contributing factor to the extreme Covid19 outbreak in North Italy. *Mol Med Rep* **21**, 2293-2295 (2020).
- .22 N. M. A. Parry, COVID-19 and pets: When pandemic meets panic. *Forensic Science International: Reports* **2**, 100090-100090 (2020).
- .23 E. M. Leroy, M. Ar Gouilh, J. Brugere-Picoux, The risk of SARS-CoV-2 transmission to pets and other wild and domestic animals strongly mandates a one-health strategy to control the COVID-19 pandemic. *One Health* 10.1016/j.onehlt.2020.100133, 100133 (2020).
- .24 J. Fatjo *et al.*, Epidemiology of Dog and Cat Abandonment in Spain (2008-2013). *Animals (Basel)* **5**, 426-441 (2015).
- .25 C. N. Carter, Pet population control: another decade without solutions? *J Am Vet Med Assoc* **197**, 192-195 (1990).
- .26 S. Burgos-Caceres, Canine Rabies: A Looming Threat to Public Health. *Animals (Basel)* **1**, 326-342 (2011).
- .27 L. A. Janssens *et al.*, The oldest case yet reported of osteoarthritis in a dog: an archaeological and radiological evaluation. *J Small Anim Pract* **57**, 568-574 (2016).
- .28 J. Lass-Hennemann, S. K. Schafer, M. R. Sopp, T. Michael, The Relationship between Dog Ownership, Psychopathological Symptoms and Health-Benefitting Factors in Occupations at Risk for Traumatization. *Int J Env Res Pub He* **17** (2020).
- .29 L. Tzivian, M. Friger, T. Kushnir, Associations between Stress and Quality of Life: Differences between Owners Keeping a Living Dog or Losing a Dog by Euthanasia. *Plos One* **10** (2015).
- .30 S. B .Barker, R. T. Barker, The human-canine bond: Closer than family ties? *Journal of Mental Health Counseling* **10**, 46-56 (1988).
- .31 D. L. Wells, Domestic dogs and human health: an overview. *Br J Health Psychol* **12**, 145-156 (2007).
- .32 S. R. Lowe, S. Joshi, R .H. Pietrzak, S. Galea, M. Cerda, Mental health and general wellness in the aftermath of Hurricane Ike. *Soc Sci Med* **124**, 162-170 (2015).
- .33 A. Marder, M. M. Duxbury, Obtaining a pet: realistic expectations. *Vet Clin North Am Small Anim Pract* **38**, 1145-11 ,62viii (2008).
- .34 S. Kumar, Stray dogs are a growing threat to public health. *BMJ* **325**, 66-66 (2002).
- .35 R. G. Pinillos *et al.*, One Welfare - a platform for improving human and animal welfare. *Vet Rec* **179**, 412-413 (2016).
- .36 S. M. Mor *et al.*, One health in our backyard: Design and evaluation of an experiential learning experience for veterinary medical students. *One Health* **5**, 57-64 (2018).
- .37 C. Panning, M. Lem, S. Bateman, Profiling a one-health model for priority populations. *Can J Public Health* **10** ,7e222-e223 (2016).

- .38 M. Lem, Serving homeless populations through a One Health approach. *Can Vet J* **60**, 1119-1120 (2019).
- .39 T. Jordan, M. Lem, One Health, One Welfare: education in practice veterinary students' experiences with Community Veterinary Outreach. *Can Vet J* **55**, 1203-1206 (2014).
- .40 C. Card, T. Epp, M. Lem, Exploring the Social Determinants of Animal Health. *J Vet Med Educ* **45**, 437-447 (2018).
- .41 M. Nagasawa, K. Mogi, T. Kikusui, Continued Distress among Abandoned Dogs in Fukushima. *Scientific Reports* **2** (2012).
- .42 R. Chadwin, Evacuation of Pets During Disasters: A Public Health Intervention to Increase Resilience. *Am J Public Health* **107**, 1413-1417 (2017).
- .43 K. E. Holland, Acquiring a Pet Dog: A Review of Factors Affecting the Decision-Making of Prospective Dog Owners. *Animals* **9** (2019).
- .44 E. Weiss, K. Miller, H. Mohan-Gibbons, C. Vela, Why Did You Choose This Pet?: Adopters and Pet Selection Preferences in Five Animal Shelters in the United States. *Animals (Basel)* **2**, 144-159 (2012).
- .45 D. L. Duffy, K. A. Kruger, J. A. Serpell, Evaluation of a behavioral assessment tool for dogs relinquished to shelters. *Prev Vet Med* **117**, 601-609 (2014).
- .46 J. Stephen, R. Ledger, Relinquishing dog owners' ability to predict behavioural problems in shelter dogs post adoption. *Applied Animal Behaviour Science* **107**, 88-99 (2007).
- .47 G. Tami, A. Gallagher, Description of the behaviour of domestic dog (*Canis familiaris*) by experienced and inexperienced people. *Applied Animal Behaviour Science* **120**, 159-169 (2009).
- .48 E. Payne, P. C. Bennett, P. D. McGreevy, Current perspectives on attachment and bonding in the dog-human dyad. *Psychol Res Behav Manag* **8**, 71-79 (2015).
- .49 E. R. Shore, Returning a recently adopted companion animal: adopters' reasons for and reactions to the failed adoption experience. *J Appl Anim Welf Sci* **8**, 187-198 (2005).
- .50 K. K. Wu, S. K. Chan, T. M. Ma, Posttraumatic stress after SARS. *Emerg Infect Dis* **11**, 1297-1300 (2005).
- .51 A. Beetz, I. Schofmann, R. Girgensohn, R. Braas, C. Ernst, Positive Effects of a Short-Term Dog-Assisted Intervention for Soldiers With Post-traumatic Stress Disorder-A Pilot Study. *Front Vet Sci* **6**, 170 (2019).

Supplementary information

The following includes 4 supplementary Tables, and 3 supplementary Figures

Supplementary Tables

Supplementary Table 1: Multiple Linear Regressions models for adoption measures

Linear Regression analyses were utilized to evaluate the effects of the spreading of COVID-19 and lockdown stages on adoption and abandonment outcomes for pet dogs, using data from the Yad4 adoption website. The table completes the information presented in the manuscript regarding these models. Each outcome variable is presented in a different section; the number of adoption requests received through the website, the number of dogs marked as adopted, as measures of the level of interest in conducting an adoption process, and the final outcome of successful adoptions; the number of uploaded dogs, as a measure of recent abandonment cases; the length of stay at the shelter, calculated from the difference between the day uploaded to the website to the day marked as adopted; the available foster families that did not get a dog; and the daily online visits on the Yad4 adoption website. The predictors were the different periods in the development of the COVID-19 pandemic, controlled for the year, month, and governmental initiatives to encourage responsible dog ownership when relevant.

Monthly number of adoption requests				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	-109.19	109.45	-331.38 to 113.00	0.325
Outbreak in Israel	789.19	149.15	486.4 to 1091.98	0.000
Full lockdown in Israel	2367.44	149.15	2064.65 to 2670.23	0.000
Gradual opening	1140.19	149.15	837.4 to 1442.98	0.000
Governmental initiatives	7.25	67.55	-129.89 to 144.39	0.915
Year	51.75	26.16	-1.36 to 104.86	0.056
Month fixed effect	Yes	Yes	Yes	Yes

Monthly number of adopted dogs				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	105.15	50.41	2.80 to 207.49	0.044
Outbreak in Israel	362.65	68.70	223.18 to 502.11	0.000
Full lockdown in Israel	359.40	68.70	219.93 to 498.86	0.000
Gradual opening	11.40	68.70	-128.07 to 150.86	0.869
Governmental initiatives	100.31	31.12	37.14 to 163.47	0.003
Year	-31.25	12.05	-55.71 to --6.79	0.014
Month fixed effect	Yes	Yes	Yes	Yes

Monthly number of abandoned dogs				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	104.40	55.15	-7.57 to 216.36	0.067
Outbreak in Israel	117.52	75.16	-35.06 to 270.10	0.127
Full lockdown in Israel	-11.98	75.16	-164.56 to 140.60	0.874
Gradual opening	-76.98	75.16	-229.56 to 75.60	0.313
Governmental initiatives	96.33	34.04	27.23 to 165.44	0.008
Year	-31.71	13.18	-58.47 to -4.94	0.022
Month fixed effect	Yes	Yes	Yes	Yes
Length of stay at the shelter				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	-24.38	10.38	-45.46 to -3.30	0.025
Outbreak in Israel	-38.55	14.15	-67.28 to -9.82	0.010
Full lockdown in Israel	-41.03	14.15	-69.76 to -12.30	0.006
Governmental initiatives	-23.27	6.41	-36.28 to -10.26	0.001
Year	-7.96	2.48	-13.00 to -2.92	0.003
Month fixed effect	Yes	Yes	Yes	Yes
Available foster families				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	208.19	33.88	139.41 to 276.97	0.000
Outbreak in Israel	534.69	46.18	440.96 to 628.42	0.000
Full lockdown in Israel	780.94	46.17	687.21 to 874.67	0.000
Governmental initiatives	88.42	20.91	45.96 to 130.87	0.000
Year	0.00	8.10	-16.44 to 16.44	1.000
Month fixed effect	Yes	Yes	139.41 to 276.97	Yes
Daily online visitors				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	147.69	104.08	-56.46 to 276.97	147.69
Outbreak in Israel	657.90	80.83	499.35 to 628.42	657.90
Full lockdown in Israel	2310.57	82.06	2149.61 to 874.67	2310.57
Gradual opening	-160.10	111.45	-378.70 to 130.87	-160.10
Year	219.16	7.47	204.50 to 16.44	219.16
Month fixed effect	Yes	Yes	Yes	Yes

Supplementary Table 2: Multiple Linear Regressions models worldwide trends of searches for adoptable dogs

Linear Regression analyses were utilized to analyze Google Trends data for searches all around the world, as well as specifically in the USA. The table completes the information presented in the manuscript regarding these models. Each outcome variable is presented in a different section; the index of web-searches worldwide and in the USA, of the words "adopt a dog" during the same period. The predictors were the different periods in the development of the COVID-19 pandemic worldwide, controlled for the year and the month; the outbreak in China, the declaration of the World Health Organization on Europe as the epicenter of the pandemic, and the gradual opening on May 2020.

Weekly index of worldwide searches for adoptable dogs				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	5.00	5.65	-6.31 to 16.31	0.380
WHO announcement of Europe	45.81	6.45	32.87 to 58.74	0.000
Gradual opening	54.38	7.19	39.98 to 68.78	0.000
Year	1.46	6.06	-10.69 to 13.61	0.811
Month fixed effect	Yes	Yes	Yes	Yes

Weekly index of USA searches for adoptable dogs				
Variable	Coefficient	SE	95% CI	P value
Outbreak in China	3.25	5.84	-8.45 to 14.95	0.580
WHO announcement of Europe	46.69	6.67	33.32 to 60.06	0.000
Gradual opening	43.98	7.43	29.10 to 58.87	0.000
Year	4.52	6.27	-8.04 to 17.08	0.474
Month fixed effect	Yes	Yes	Yes	Yes

Supplementary Table 3: Odds Ratio of dog's life quality, behavioral problems and relinquishment by the owner

Analyses of responses to dog owners' questionnaire using logistic regression. The table completes the information presented in the manuscript regarding these models. Each section represents a different model of binary outcome: (1) the quality of life of the dog (as assessed by the owner); (2) the development of new behavioral problems (recognized and defined by the owners); (3) whether the owner was considering to relinquish the dog. Predictor: impaired quality of life of the owner. Characteristics of the dog and the owner were controlled in the model: owners' gender, age, whether there are young kids in their household (under 18 years old), and geographical region. Dog characteristics: age, whether it was adopted from a registered shelter, number of years with the owner. Ownership characteristics (as reported by the owner): number of walks a day, the average duration of the walks, and general estimation of change in their attention to the dog (1- decreased, 2- no change, 3-increased).

High quality of life of the dog			
Variable	Odds Ratio	95% CI	P value
Owners' impaired quality of life index	0.89	0.80 to 0.98	0.019
Owners' change in routine life	1.08	1.00 to 1.17	0.055
Age of the participants	1.13	1.02 to 1.25	0.023
Age of the dog	0.98	0.95 to 1.01	0.207
Female gender	1.14	0.91 to 1.43	0.254
Kids under 18 years old in the house	1.28	1.07 to 1.53	0.007
Central region of Israel	1.19	0.98 to 1.45	0.082
Southern region of Israel	1.20	0.89 to 1.60	0.229
Number of years with the dog	1.02	0.99 to 1.04	0.211
Adopted dogs	1.01	0.84 to 1.21	0.926
Sterilized dog	0.87	0.68 to 1.12	0.296
Dog lives In-Out	1.23	0.99 to 1.53	0.067
Number of daily walks	1.15	1.06 to 1.25	0.001
Average length of a walk	1.03	1.02 to 1.04	0.000
Increased attention to the dog	4.95	4.17 to 5.87	0.000

Development of new behavioral problems (recognized by owners)			
Variable	Odds Ratio	95% CI	P value
Owners' impaired quality of life index	1.40	1.22 to 1.61	0.000
Owners' change in routine life	1.19	1.05 to 1.35	0.006
Age of the participants	0.85	0.73 to 0.98	0.028
Age of the dog	0.99	0.95 to 1.04	0.790
Female gender	0.96	0.70 to 1.32	0.811
Kids under 18 years old in the house	0.77	0.60 to 1.00	0.053
Central region of Israel	1.49	1.10 to 2.01	0.009
Southern region of Israel	1.08	0.69 to 1.70	0.732
Number of years with the dog	0.97	0.92 to 1.01	0.143
Adopted dogs	1.70	1.31 to 2.21	0.000

Sterilized dog	1.34	0.90 to 2.00	0.153
Dog lives In-Out	0.94	0.69 to 1.30	0.730
Number of daily walks	1.04	0.93 to 1.17	0.473
Average length of a walk	1.00	0.98 to 1.01	0.654
Increased attention to the dog	1.14	0.91 to 1.44	0.260

Owners' intention to relinquish their dog

Variable	Odds Ratio	95% CI	P value
Owners' impaired quality of life index	1.76	1.16 to 2.67	0.008
Owners' change in routine life	0.73	0.53 to 1.00	0.053
Age of the participants	1.05	0.68 to 1.62	0.830
Age of the dog	1.03	0.87 to 1.22	0.737
Female gender	0.31	0.15 to 0.66	0.002
Kids under 18 years old in the house	0.96	0.44 to 2.08	0.921
Central region of Israel	0.00	0.40 to 2.19	0.874
Southern region of Israel	0.93	0.41 to 4.02	0.675
Number of years with the dog	1.28	0.65 to 0.99	0.037
Adopted dogs	0.80	0.44 to 2.01	0.880
Sterilized dog	0.94	0.81 to 16.47	0.091
Dog lives In-Out	3.66	0.55 to 3.11	0.545
Number of daily walks	1.31	0.62 to 1.25	0.484
Average length of a walk	0.88	0.97 to 1.05	0.643
Increased attention to the dog	1.01	0.79 to 3.50	0.183

Supplementary Table 4: behavior and physiologic change of the dog as recognized by their owners

An online digital questionnaire targeting dog owners in Israel was active during the COVID-19 related full lockdown, as detailed in the manuscript. The distribution of replies of a multiple choice question regarding the type of behavioral and physiological changes in dogs, as recognized and defined by their owners, of the owner reported on changes in the dog behavior.

Behavior and physiological change	Frequency	Percent
Hypersensitivity to noise	115	4%
Self Mutilation	17	0.6%
Change in appetite	87	3%
Hiding for no reason	16	0.6%
Sharp changes in temperament	39	1.3%
Panting and/or drooling	23	0.8%
Whining, barking for no reason	50	1.7%
Gastro-intestinal problems (e.g. diarrhea)	21	0.7%
Increase in asking for attention	269	9.3%
Seemed less stressed	66	2.3%
Seemed more calm	127	4.4%

Supplementary figures

Supplementary Figure 1: dog's length of stay at the shelter before and during the COVID-19 pandemic

Linear Regression to predict dog's length of stay at the shelter in each of the relevant periods, as compared to before the pandemic. Predictors: the different periods, from the outbreak in China to outbreak in Israel, the developments in Israel until full lockdown and the full lockdown. Each period was compared to the period from 2016 until the outbreak in China (presented in the horizontal dotted line). Controlled for: year, month, governmental initiatives for dog adoption in 2019. Data is presented as coefficients (sign) and 95% confidence interval (bars) ($P < 0.05$).

Supplementary Figure 2: frequencies of the change in routine life, as reported by dog's owners

An online digital questionnaire targeting dog owners in Israel was active during the COVID-19 related full lockdown, as detailed in the manuscript. The figure presents the dog owners' answers to the question, “to what extent was your daily routine changed during this time?” (on a scale of 1 to 5). The columns represent frequencies of the participants based on their answers.

Supplementary Figure 3: descriptive statistics of the backgrounds of the participants' dogs

An online digital questionnaire targeting dog owners in Israel was active during the COVID-19 related full lockdown, as detailed in the manuscript. The pie charts include the frequencies of (a) the source of the dog and (b) where the dog lives, as reported by the owners. Among the dogs, 84% were sterilized (i.e., castrated or neutered), similar to the sterilization rate among the owned dog population in Israel. The average age of the dogs was 6.2 ± 4.1 years; and the average ownership period was 5.5 ± 4.6 years.