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Home Gardening and Food Security Concerns during the COVID-19 Pandemic

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Abstract: At times of crisis, home gardening has often been sought out as a potential solution for threats to food security and as a measure to increase socio-psychological effects, such as public sense of self-efficacy, trust in the government and care for one's wellbeing. The objective of this study was to investigate if home gardening increased during the COVID-19 pandemic in the spring/summer of 2020 and to provide socio-psychological insights into the explanatory factors of such an increase. An explanatory theoretical model of home gardening was proposed and tested to analyse whether home gardening is correlated to food security concerns, and if so, to what extent. A non-representative survey was conducted in five European countries (Slovenia, Norway, Estonia, Switzerland, and Iceland) using snowball sampling via social media networks, reaching 1144 participants. The results showed the pandemic did prove to be an important psychological push towards home gardening prompted by food security concerns. Measured as loose as introducing at least one new gardening activity during COVID-19, this study found an approximately 10% increase in home gardening during the first wave of COVID-19 in the sample population, which was skewed towards educated, female, middle-class Europeans.

Keywords: food security; home gardening; COVID-19; food security concerns; wellbeing; behavioural change; protection motivation theory

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1. Introduction

At times of crisis, home gardening (or household gardening) has often been sought as a potential solution for threats to food security. The United Kingdom's "Dig for Victory" campaign during WWI promoted home gardening, not only for food security reasons, but also for effects on people's sense of trust and as an extension of government order into the domestic sphere [1]. The COVID-19 pandemic has witnessed a return to these historical events in the search for solutions to food security in times of crisis [2,3].

The past decade saw increased attention to home gardening, primarily with a focus on urban farming in the context of food security and rising urbanization [4]. The many environmental challenges (including climate change) are aggravated in an urban environment and can influence the health of the inhabitants. Urban agriculture is said to alleviate these adverse effects [5]. Knowledge on managing urban gardens, agriculture and water systems in historic cities has contributed to long-term food security [6]. Taylor and Taylor Lovell [7] found that urban home food gardens strengthen community self-reliance, are

sites of cultural reproduction, contribute to biodiversity and create better access to resources (so-called luxury effect).

Before the COVID-19 pandemic, home gardening outside the urban environment had been considered a potentially viable measure for food security, especially in low-income countries, focusing to a large extent on the African continent [8–10], and in the case of Europe, on Eastern Europe [11,12]. After the pandemic, the perception of home gardening as a viable measure for food security intensified for urban and non-urban areas in Africa [13,14] and other continents [15], including Europe [16,17].

As several authors pointed out, all pillars of food security were threatened by the COVID-19 pandemic, both in high-income and low-income countries [18–23]. Consequences of the pandemic, such as temporary loss of job and income, and mobility restrictions, led to increase in costs related to food purchase, disruption in access to food outlets of choice and loss of access to convenient food supply outlets. This led to reduced food quantity, caused by a decrease in consumers' purchasing power and access to food, as well as degradation in food quality (e.g., shift to cheaper, less nutritious food) and, thus, increased the risk of exposure to unsafe food [19,23].

Previous research on the public response to food security at the time of the pandemic identified high levels of consumer concerns, resulting, primarily, in changes in food procurement [24], stockpiling [25], more sustainable food purchasing [26], reduction of food waste [27], food preservation and changes in eating behaviour [28], and diet quality [29].

It seemed that the COVID-19 pandemic, with its partially broken supply chains [30] and consequences for several aspects of food security, started to shift sentiments in favour of home gardening again. In Europe, before the pandemic, home gardening and non-professional urban gardening was perceived as a social benefit (i.e., improving one's general health [31] and wellbeing or community connections [32]), and not as a significant contribution towards food security. Home gardening was either regarded as a viable option for low-income countries [33] or as an element of the past crises, most remembered within the "Victory Gardens" movement of the two World Wars [1,34]. However, there are only few empirical studies which analyse whether COVID-19 really increased home gardening behaviour. In the next chapter we provide the overview of the current discussions and available empirical data on home gardening during the COVID-19 pandemic.

1.1. Investigation Background: Food Security and Home Gardening during the COVID-19 Pandemic

During the COVID-19 pandemic, the theoretical focus on urban farming intensified. Lal [35] stressed the role of home gardening and urban agriculture in increasing food security in cities. Loker and Francis [36] postulated that the crisis should lead to changes in the food system, with increased food production closer to consumers. Pulighe and Lupia [37] noted that COVID-19 exposed the weaknesses of food systems in large cities, which should be counteracted with developments in urban agriculture and the inclusion of edible green infrastructures into cities. Romanova and Lovell [38] recognized the contributions of urban gardens towards stormwater mitigation and food security, while at the same time warned about potential food health and safety risks of urban landscapes used for edibles. Hume et al. [39] calculated the potentials of urban gardening in Adelaide, Australia, and concluded that self-sufficiency through backyard vegetable production is plausible.

Sofo and Sofo [40] predicted an increased interest in home gardening after the start of the pandemic and provided practical advice for using available space, albeit there has been little empirical research performed so far to test these predictions, with only a few exceptions. Most research has focused on the role of home gardening as a coping mechanism for pandemic-related stress. [41–43] For example, focusing on the elderly, Corley et al. [44] found indications of positive health benefits (self-rated physical health, emotional and mental health, etc.) of home gardening during COVID-19.

Kampman et al. [45] compared the situation in the Philippines and Senegal to show how the increase of interest in urban gardening during COVID-19 has been shaped by, and

elicited different reactions from, governments and communities. As part of food literacy increase during COVID-19, Charlebois et al. [46] report that Canadians have taken up gardening. A total of 51% of participants in their sample of 10,004 claimed to have grown fruits or vegetables at home, and 58% of participants intended to do so in 2021.

Chenarides et al. [47] discovered that home gardening before COVID-19 was practiced by larger households and employed respondents, yet, during the pandemic, it was more likely to occur when children were in the household and households were younger and more educated. Contrary to the hopes put forward regarding the rise of home gardening, they discovered that both home and community gardening fell in 2020 compared to 2017. They concluded that participation in small-scale urban agriculture during a pandemic had its challenges, with barriers to adoption being that many nurseries selling plants and seeds were considered non-essential businesses. Therefore, acquiring the resources necessary to grow food at home affected the ability to adopt home or community gardening.

There have been only anecdotal accounts that the COVID-19 pandemic caused an increased interest in home gardening, as indicated by seed and supply shortages in the USA [48] and the UK, for example. In Switzerland the focus has been on the self-sufficiency of seed production in case the supply chains are broken [49]. Sperling et al. [50] outlined recommendations prepared by seed system experts to ensure seed supply, especially for smallholder farmers. Similarly, in Norway, new national strategies for urban agriculture have been developed and employed under the COVID-19 pandemic [51]. Schools adopted a new national curriculum teaching young people to experience nature, its benefits and practical challenges with food production as an arena for learning and life skills [52].

The aim of this research is twofold: first, to provide empirical insights into whether the COVID-19 pandemic increased interest in home gardening in the selected European countries. Second, to build and test an explanatory model of home gardening, focusing specifically on the question of whether home gardening of survey participants could be attributed to factors beyond general attitudes and wellbeing benefits to food-safety concerns at the time of the pandemic. In the next section, we turn to the theoretical model we built to identify the variables affecting individual home gardening.

1.2. Theoretical Model

Several papers have stressed the benefits of home gardening both for the individual and the community. For example, Libman [53] found that gardening helped young people recognize how hard it is to grow food and how much effort, time, and physical labour it takes to grow vegetables, raising the consciousness about the value of food. Kortright and Wakefield [54] found that growing food contributes to food security at all income levels by encouraging a more nutritious diet. The sustainability of household food sourcing and gardeners' overall health and well-being also increased with food production. Growing vegetables helped to improve the health and well-being of older cancer survivors, who, in addition, cultivated healthy behaviour in vegetable and fruit consumption [55].

Past research also showed important benefits of home gardening, especially for the health and community connections of the elderly [56–58]. Grebitus [59] revealed that trust, attitude, and knowledge affect the growing of produce at home, while the drivers of community gardening are involvement and personality profile. Regarding socio-demographics, her research showed that household size affects the growing of produce at home, while gender, age, and income affect community gardening.

We have set out to test an explanatory model, as described in Figure 1. The model follows the classical Protection Motivation Theory (PMT) [60,61], whereby perceived threat is one of the main motivational drivers for behavioural change.

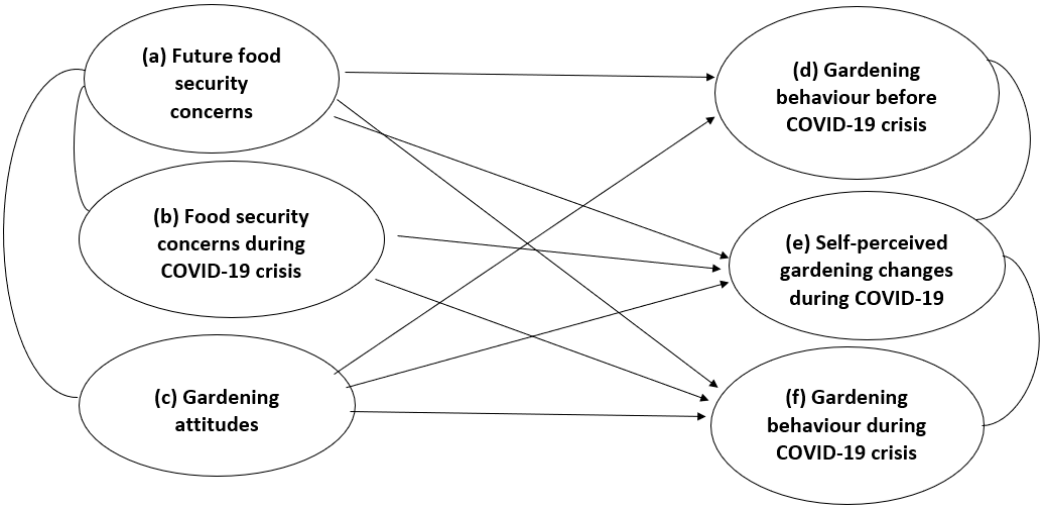

Figure 1. Theoretical model of gardening behaviour, based on protection motivation theory [60,61], before and during COVID-19 crisis.

We focus on the question of whether attitudes towards home gardening during COVID-19 can be attributed to fear, i.e., food security concerns. We identify here two types of food security concerns: (a) "future food security concerns", defined as perception of the probability that food security will be a significant risk in the future; and (b) "food security concerns during the COVID-19 crisis", defined as the level of worry regarding the availability of fresh fruit and vegetables during the COVID-19 crisis.

The third variable which hypothetically affects gardening behaviour, according to the model (Figure 1), is (c) "gardening attitudes", defined here as the level of expressed positive gains one receives via home gardening in relation to the availability of necessary means to a home garden. This variable thus includes both positive attitudes regarding gardening (heightening one's wellbeing, improving food security, saving money) and negative attitudes (gardening as not necessary or requesting resources or knowledge one does not possess).

We hypothesized that "future food security concerns" and "gardening attitudes" variables correlate with the variable (d) "gardening behaviour before COVID-19 crisis", defined and operationalized here as the sum of all specific home gardening behaviours performed before the COVID-19 crisis.

Finally, we predicted that all these variables correlate with the variable (e) "self-perceived gardening changes during COVID-19", defined here as the extent to which one proclaims that COVID-19 caused gardening behaviour and interests. Since self-perceptions can be subject to a great extent of subjectivity (e.g., sustainable behaviour has been shown to be over-estimated by a factor of four) [62], we aimed to also measure the variable of exact gardening behaviour (f) "gardening behaviour during COVID-19 crisis", defined and operationalized here as the sum of all those home gardening activities one introduced after the start of the COVID-19 crisis.

2. Materials and Methods

2.1. Methods

We used an online questionnaire in which we operationalized variables of the theoretical model and standard demographic variables. Gardening behaviour was measured on a binary scale ("yes", "no") for a set of gardening activities performed before or after the start of the COVID-19 crisis. All other variables were measured on a 5-point Likert scale.

We processed the acquired data in Microsoft Excel 2013 and IBM SPSS v.23. For basic data analysis and for graphical representations, we used Excel's built-in functions. IBM SPSS version 23 was used for statistical analyses. We performed factor analysis for variables measuring attitudes and concerns (extraction method: principal axis factoring). Since the

data was not normally distributed (as tested by Kolmogorov-Smirnov Test and measures of skewness and kurtosis), and most variables were nominal or ordinal, we used non-parametric tests (Kruskal-Wallis and Mann-Whitney U Test for independent samples) to analyse the differences between groups with regards to demographic data (education, social class, size of population in place of residence, gender). For the same reason, and because, in the case of gardening behaviour, we cannot claim that the variables are continuous, we used Spearman correlation coefficient to analyse correlation between variables of the theoretical model (see Figure 1). However, we also calculated the logistic regression analysis for the dependent variable self-perceived gardening changes during COVID-19 since even though the limitations are the non-normal distribution and the limited continuous character of the variable, regression analysis provides an insight into potential partial regression coefficients, which cannot be identified with the Spearman correlation coefficients.

2.2. Sample Description

Sampling took place from June to September 2020, which is now known as the first wave of the COVID-19 pandemic in Europe. The survey was translated into five European languages and dispersed in five European countries: Switzerland, Norway, Estonia, Iceland, and Slovenia.

The countries participating in this study have roughly similar levels of self-sufficiency in produce (Table 1). Home gardening has a long tradition in all of these countries. For example, Icelandic citizens of all ages can rent a spot in the outskirts of Reykjavik and grow produce, the focus of which is mainly potatoes, beets, and cabbage. Similarly, home gardening is very high in Slovenia, where the national statistics office reports that almost two thirds (60%) of Slovenes produced their own vegetables in 2020 [63]. Estonian historic background has an important role in the home gardening tradition [64].

Table 1. National statistical data on the degree of self-sufficiency in participating countries (fraction of own production of total consumption, in percent).

Country	Switzerland [65]	Norway [51]	Estonia [66]	Iceland [67]	Slovenia [68,69]
Year	2018	2019	2019	2019	2019
Potato	80%	70.3%	80%	70%	46.6%
Vegetables	50%	46.7%	50%	43%	43.3%
Fruit	31%	3.4%	12%	-	44.1%
Pome fruit	101%	-	-	-	-
Berries	(included in Fruit)	31.8%	-	-	-

The sample included 1144 individuals; however, some chose not to answer all sociodemographic questions. In the Table 2 we give the number of valid answers for each aspect separately.

An important limitation resulting from the sampling approach was the specificity of the sample and, thus, the biases towards female gender (73.9%), higher education, and higher social class (Table 2). The sample was, therefore, unrepresentative in terms of gender regarding the population of the involved countries.

Contrastingly, the sample was representative through the prism of rural versus urban: 31.9% of respondents lived in rural areas (in a place with less than 2000 inhabitants), while 41.8% of respondents lived in small towns (2000–50,000 inhabitants) and 27.4% in large urban areas (above 50,000 inhabitants).

The limitations of sampling should be kept in mind when interpreting the results. The value of this research lies primarily in generalizing the correlation between attitudes and behaviours related to food security and the COVID-19 crisis. In this respect, we do not expect differences between our unrepresentative sample and a truly representative sample of involved countries.

Table 2. Sample description.

Aspect	Fraction of Valid Answers (%)
Gender (n_{valid} = 993)	
- Male	26.1
- Female	73.9
Age (n_{valid} = 454) (average: 43.64 years, STD: 13.57 years)	
- 20 years or less	2.0
- 21 to 35 years	27.1
- 36 to 55 years	48.7
- 56 years or more	22.2
Education (n_{valid} = 999)	
- High school or less	24.0
- College	13.6
- University	37.5
- Specialist study, master's degree, doctorate	32.9
Population size of place of residence (n_{valid} = 972)	
- <2000 inhabitants	30.9
- 2000–50,000 inhabitants	41.8
- >50,000 inhabitants	27.4
Self-classification in social class (n_{valid} = 897)	
- Lower middle class, lower class or working class	19.4
- Middle class	53.0
- Upper middle class or upper class	27.6
Country of current residence (n_{valid} = 913)	
- Slovenia	47.6
- Norway	21.9
- Estonia	9.31
- Switzerland	4.70
- Iceland	4.38
- Other—Europe	13.91
- Other—World	1.64

3. Results

We divided the results description into three sections. In the first section, we separated gardening behaviour before and during the COVID-19 crisis, as well as the differences between the groups according to demographic factors. In the second section, we analysed gardening attitudes and food security concerns and the effect of demographic factors on these variables. Finally, in the third section, we tested the theoretical explanatory model of gardening behaviour, as explained by food security concerns and gardening attitudes.

3.1. Increased Interest in Home Gardening during COVID-19

We assessed the level to which respondents claimed that gardening became more important to them during the COVID-19 crisis.

An important limitation of growth of gardening activities might be the fact that the participants do not see the need to extend their home gardening plans, since they were already active gardeners. The mean for this item (2.6, see Figure 2) shows that most participants disagreed with this statement. On the other hand, most participants agreed that COVID-19 did bring about some changes in their home gardening, either via the cognitive aspect (mean = 3.33) or, even more so, via the behavioural aspect (mean = 4.07) (see Figure 2).

The principal component factor analysis showed one factor and the reliability test for this set of questions showed low reliability, with, especially, the first item having very low factor values (Table A1 in Appendix A). For further analysis we, thus, excluded the first item and calculated the average of only two of these indicators as the index of "self-perceived gardening during COVID-19", whereby the variable included both changes in behavioural and the cognitive dimension of interest for home gardening.

To account for potential errors in self-perceived changes in the perceived influence of the pandemic in one's gardening behaviour, we asked the participants about their specific gardening activities and the time when these were introduced: before or after the start of the pandemic.

Table 3 shows that before the crisis the most common gardening activity was to have a square in one's lawn, producing fruit and/or vegetables: 54.3% of survey participants had this before the pandemic. A percentage of 2.1% of participants claimed they introduced this activity in the few months after the start of the pandemic. This was followed closely by gardening in pots on the windowsill (50.1% before, with a 2.3% increase after), in containers on the balcony, terrace or similar (49.4% before, with a 1.9% increase after), in a raised bed (37.6% before, with a 2.4% increase after).

The largest growth in activities after the pandemic was in owning a greenhouse (25.5% before, with a 3.1% increase after). Most other activities were below 10% before the pandemic with less than 1% increase in each. From the sample population, 69.7% claimed they performed at least one or more gardening activity before COVID-19 and 10.1% claimed they introduced at least one new type of gardening activity during COVID-19.

The sample was, thus, skewed towards home gardening enthusiasts, although there was a lack of comparable data. Compared to the statistics from Slovenia [63], our sample showed approximately 10% more interest in home gardening. We assume this was due to the online voluntary nature of the survey: those who were more interested in gardening were more likely to be motivated to answer the survey. Therefore, the data needs to be analysed from a cautionary perspective. Consequently, rather than claiming that amongst the general population COVID-19 increased interest in home gardening, we claim here that amongst those who are more interested in home gardening, the pandemic accounted for an approx. 10% increase in home gardening, which is, taken with caution, still an important result, supporting theoretical hopes that with the pandemic we could see an increase in home gardening.

For further analysis we calculated the sum of one's gardening activities, as two variables: "gardening behaviour before COVID-19" and "gardening behaviour during COVID-19". Since the activities cannot be considered as having equal weights in one's gardening behaviour, the indices as a simple sum of activities needed to be considered with limitations. We assumed here that even though the activities did not have the same weight and that there was potentially a large difference between value categories, we could still assume they reflected a meaningful order. We considered the two indices, thus, as ordinal variables with unequal differences between categories (consequently also limiting the multivariate analysis to the Mann-Whitney U-test).

We furthermore analysed the influence of demographic factors on all three types of gardening behaviour (Table 4). No statistically significant correlation was found between the age of respondents and their gardening behaviour, either before or after COVID-19. The same was true for the gender of respondents. The analysis of differences between groups with regards to education, social class, and place of residence showed a different picture.

Amongst these three, only education correlated with all three variables of gardening behaviour (Table 4 and Table A2 in the Appendix A).

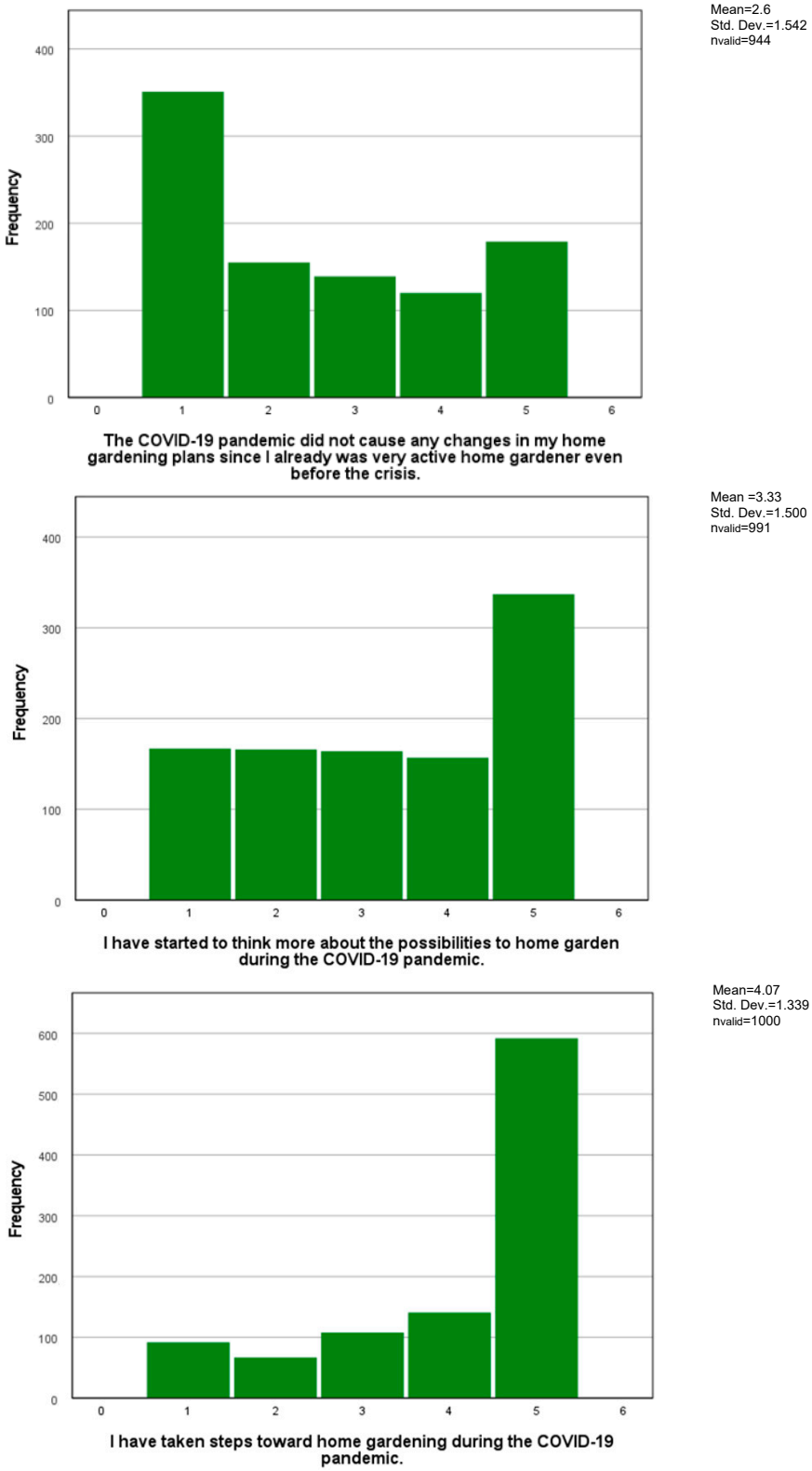

Figure 2. Mean values of items measuring "self-perceived gardening changes during COVID-19", Likert-type scale, 1 = strongly disagree, 5 = strongly agree.

Table 3. Gardening behaviour before and during COVID-19 crisis, reported as the fractions of valid answers.

Gardening Activities	No	Yes—Already before the COVID-19 Pandemic (n_{valid} = 977)	Yes—But Only during COVID-19 (n_{valid} = 947)
	Fraction of Valid Answers (%)		
I have a square in my lawn producing fruit and/or vegetables	43.6	54.3	2.1
I grow herbs in pots on the windowsill	45.0	50.1	2.3
I grow herbs and some fruit and/or vegetables in containers on the balcony or terrace or deck or rooftop	57.7	40.4	1.9
I have a raised bed in my backyard	60.0	37.6	2.4
I have a greenhouse in my garden producing fruits and/or vegetables	69.5	27.5	3.1
I have small vertical farming in my backyard or my balcony or elsewhere in my home	87.5	12.1	0.4
I have a self-made indoor garden	91.4	7.7	0.9
I am a member of a local cooperative society producing fruits and/or vegetables	94.1	5.3	0.6
I have an indoor garden that I bought as a kit	94.7	4.9	0.4
I dedicated a part of my flat green roof to fruit and/or vegetable production	96.4	3.4	0.2
I have a small aquaponic unit in my backyard or elsewhere in my home	96.7	2.6	0.7

Table 4. Compared means between groups (education, social class, population's size of place of residence, gender) for three aspects of gardening behaviour.

	Education			Social Class			Population Size of Place of Residence			Gender	
	Vocational or Less	Bachelors	Masters or Higher	Lower	Middle	Upper	2000<	2001 < 50,000	50,000<	Female	Male
Gardening behaviour before COVID-19	0.75	0.72	0.62	0.71	0.72	0.66	0.87	0.68	0.52	0.71	0.66
Self-perceived gardening changes during COVID-19	3.80	3.65	3.66	3.77	3.66	3. 73	3.77	3.71	3.66	3.65	3.87
Gardening behaviour during COVID-19	0.07	0.10	0.14	0.08	0.11	0.10	0.07	0.11	0.11	0.10	0.09

Further analysis showed that the difference between groups was not a unilateral correlation that would follow a simple pattern of, for example, the higher education the less or more common home gardening. Rather, with regards to gardening before the pandemic, home gardening was more common amongst participants with lower education, whilst the self-perceived gardening changes during COVID-19 and gardening activities after COVID-19 showed the opposite picture: the higher the education the more the participants

claimed that the pandemic increased their interest in home gardening and the more often they started a new gardening activity after the pandemic.

The analysis of self-identified social class showed differences between groups only for gardening behaviour before COVID-19, whereby home gardening was more common both amongst those who claimed they belonged to the working class and upper higher class, while lower for those in the middle class.

Finally, the analysis of the urban versus rural samples (population size of place of residence below 2000 inhabitants, Table 4) showed gardening to be more common in rural areas before COVID-19. On the contrary, the self-perceived gardening changes during COVID-19 were higher for residents in urban areas. However, this was not confirmed for the actual activities measured with gardening behaviour during COVID-19. Here there was no statistical difference with regards to population size of place of residence.

3.2. Food Security Concerns

For the series of questions that measured one's fear of future food security, principal component factor analysis showed only one factor, which we termed "future food security concerns" (see Appendix A, Table A3). For this factor, 57.47% of the total variance was explained. Cronbach's alpha (0.78) showed the high reliability of the measuring instrument, so we can conclude that the questions were designed in a meaningful way and together measured one dimension of fear about food security in the future.

On average (Figure 3), respondents were only moderately concerned about future food security (1.4). The highest value was expressed for the item "Food insecurity poses the greatest threat to humanity in the near future." The participants generally judged less risk for themselves than for others. The results, thus, reflected the so-called optimism bias, namely, the tendency for people to think they are less at risk than the average person [70]. This is in line with other research on COVID-19 as a threat [71].

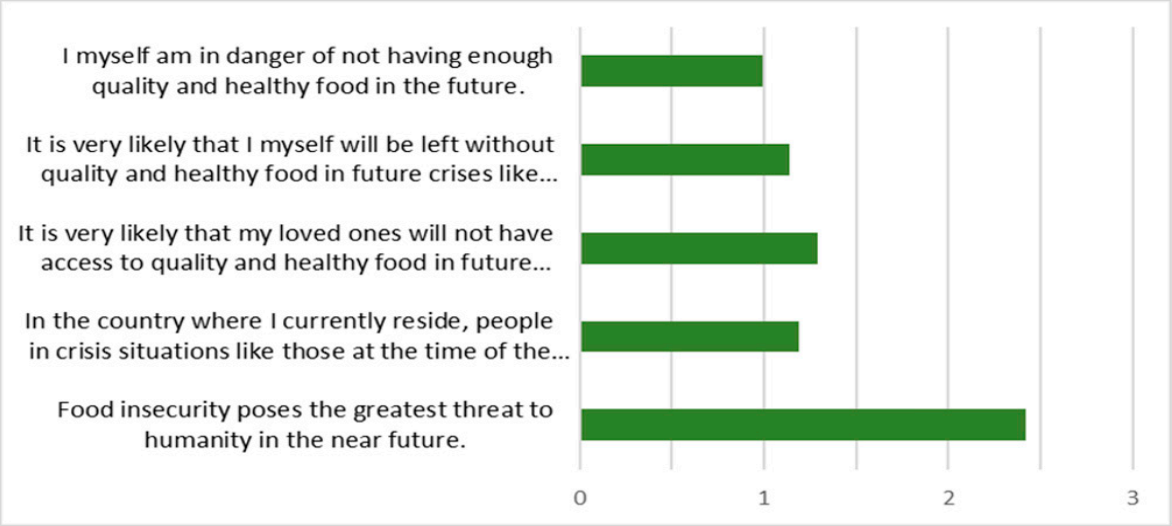

Figure 3. Mean values of items measuring "future food security concerns", Likert scale, 1 = strongly disagree, 5 = strongly agree (n_{valid} = 931, see Table A3 in Appendix A for full data).

Furthermore, we aimed to measure food security concerns during the COVID-19 crisis. Factor analysis of items measuring this variable showed one factor that explained 51.09% of the total variance, and the reliability test for this set of questions showed moderate reliability (Cronbach's alpha: 0.785) (Table A4 in Appendix A). Thus, we concluded that the composite scale was content-appropriate, and all the questions were within the same scope. Similarly, as with the future food security concern, here too the average was very low (Figure 4).

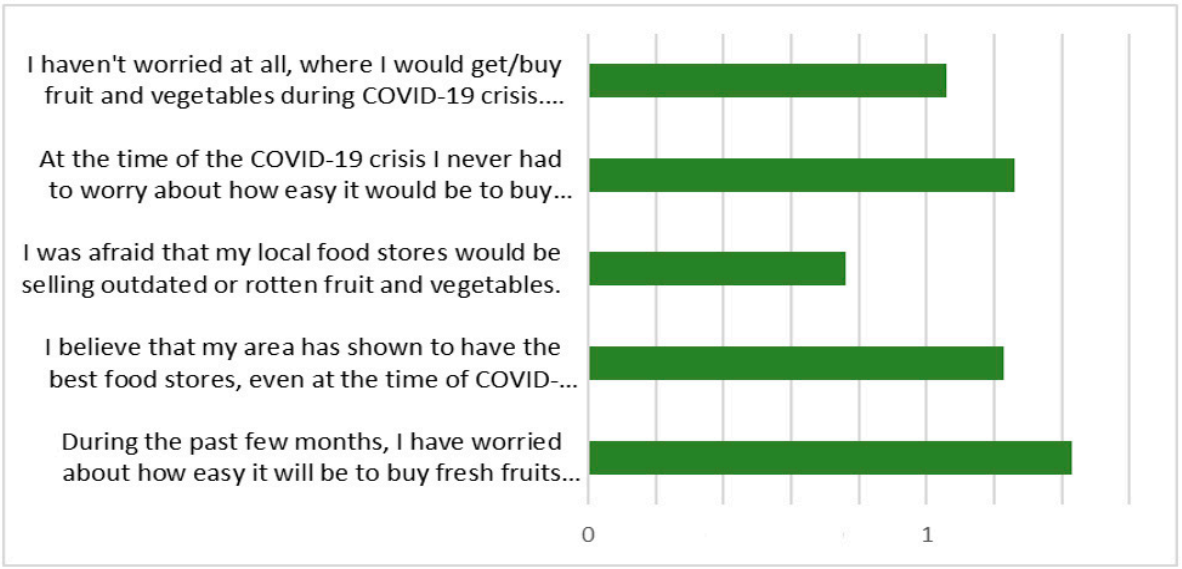

Figure 4. Mean values of items measuring "food security concerns during the COVID-19 crisis", Likert scale, 1 = strongly disagree, 5 = strongly agree (n_{valid} = 1035, see Table A4 in the Appendix A for full data).

Most respondents were not concerned about the availability of fresh fruit and vegetables at the time. Especially the level of trust in the quality of produce sold, measured with the statement, "I was afraid that my local food stores would be selling outdated or rotten fruit and vegetables", received a very low level of concern on average (average was 0.76 on a five-point scale).

3.3. Gardening Attitudes

For the questions that measured gardening attitudes, factor analysis with principal component analysis again showed two factors, with which we could explain 64.9% of the total variance (Table A5 in Appendix A). Cronbach's alpha (0.631) showed relatively low reliability of the measuring instrument for both components together. However, it rose above 0.8 if the two components were analysed separately, thus, showing satisfactory reliability for components individually. The factor analysis showed two factors, the difference between which, however, was primarily in the direction of attitudes. We, thus, termed the two components as "positive gardening attitudes" and "negative gardening attitudes".

Figure 5 shows a relatively high average for the items measuring positive attitudes towards home gardening, with mean values for all items reaching over 2.5 on a 5-level scale. The highest mean was judged for the item "Home gardening relaxes me and in this way is an effective way for me to stay healthy", confirming the importance of home gardening for one's wellbeing, as shown by previous research. The lowest mean, reaching just above 2.5, was for the item "Home gardening enables me to save more money, when buying food, because I produce some food by myself". This shows that the participants did not perceive home gardening as a highly effective means to save money, probably because home gardening could not compete with the economy of scale in professional agriculture. Finally, the two items asking about one's attitude towards home gardening in relation to food security showed a relatively positive evaluation of home gardening (in both cases, the mean value was close to 2.8).

Similarly, Figure 6 shows relatively positive attitudes when reverse questions were asked (since these were negative attitudes, all the statements were reverse recoded to be in line with the direction of positive attitudes). The highest reverse recoded value was for the general statement about interest in home gardening (mean was above 3), showing, thus, that the participants had overall highly positive attitudes towards gardening. Amongst the barriers for home gardening, knowledge and resources seemed to be on approximately the

same level, although generally not very high (reverse recoded mean was close to 3 on a 5-level scale).

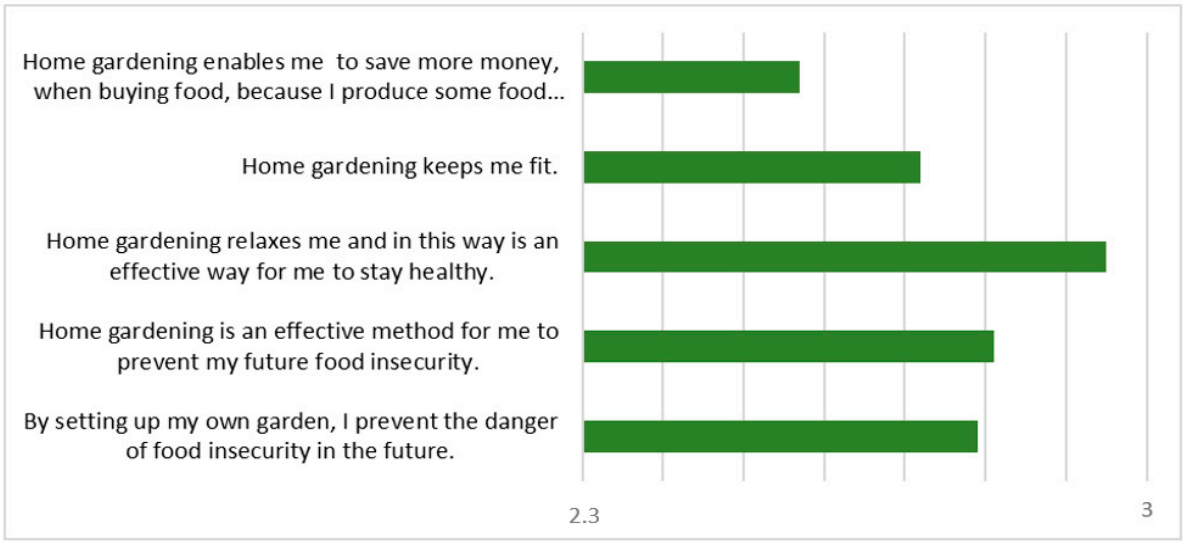

Figure 5. Mean values of items measuring "positive gardening attitudes", Likert scale, 1 = strongly disagree, 5 = strongly agree (n_{valid} = 924, see Table A5 in Appendix A for full data).

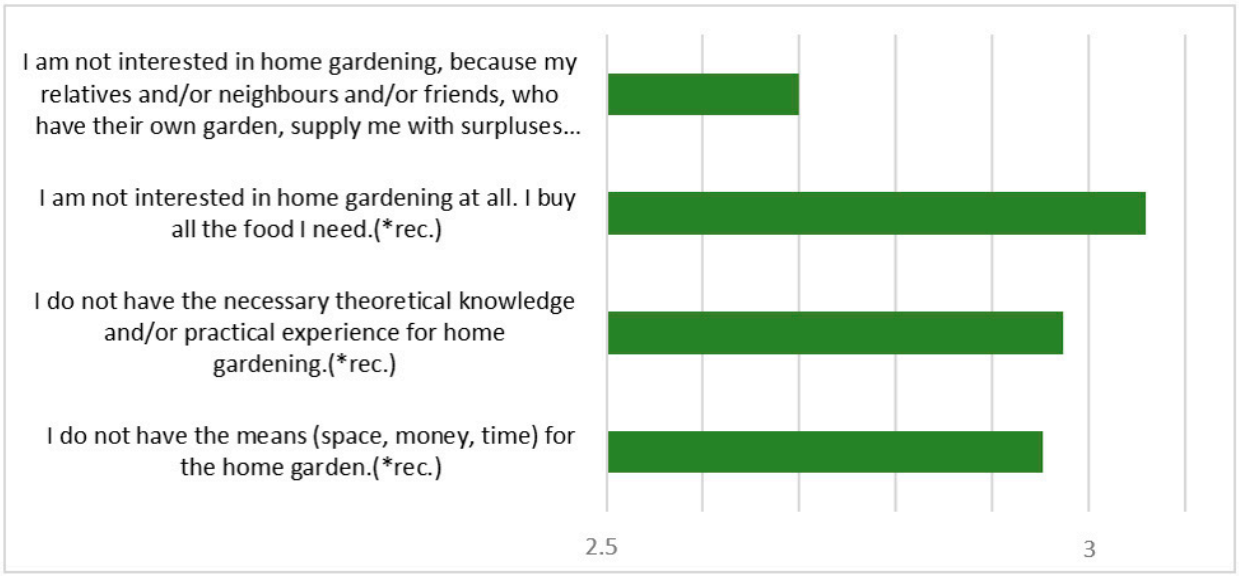

Figure 6. Mean values of items measuring "positive gardening attitudes", Likert scale, 1 = strongly disagree, 5 = strongly agree, * rec: statement is reverse recoded (n_{valid} = 975, see Table A4 in Appendix A for full data).

Furthermore, we analysed the differences in food security concerns and gardening attitudes according to demographic variables. Table 5 shows the compared means between groups (and Table A6 in the Appendix A, the results of the nonparametric tests of differences between groups). The results showed no significant differences for food security concerns, both in the future and during COVID-19. There were, however, statistical differences in gardening attitudes for the four demographic variables (education, social class, place of residence and gender). While all four affected positive gardening attitudes, only social class and gender did not affect negative gardening attitudes.

Table 5. Compared means between groups (education, social class, population's size of place of residence, gender) for future food security concerns, food security concerns during COVID-19, positive gardening attitudes and negative gardening attitudes (* rec: index is reverse recoded).

	Education			Social Class			Population Size of Place of Residence			Gender	
	Vocational or Less	Bachelors	Masters or Higher	Lower	Middle	Upper	2000<	2001 < 50,000	50,000<	Female	Male
Future food security concerns	3.52	3.60	3.66	3.51	3.60	3.65	3.51	3.66	3.66	3.58	3.66
Food security concerns during COVID-19	3.82	3.88	3.83	3.76	3.84	3.92	3.78	3.85	3.95	3.82	3.93
Positive gardening attitudes	2.00	2.19	2.40	1.92	2.23	2.28	1.85	2.23	2.46	2.11	2.43
Negative gardening attitudes (* rec)	3.33	3.01	2.43	3.03	2.99	2.78	3.31	2.81	2.68	2.95	2.83

Similar results were shown for age, which had a statistically significant effect on both types of gardening attitudes and future food security concerns. There was, however, no statistically significant difference according to age in food security concerns during COVID-19; both younger and older participants were equally concerned during the crisis (Table A6 in the Appendix A).

Additionally, we analysed the differences between countries and the results (not shown) were inconclusive: mostly there were no differences between countries, and in the few cases where there were significant differences between pairs of countries, there did not seem to be any common conclusion possible. More research is, thus, needed in order to analyse the role of social and geo-political differences in home gardening.

3.4. Testing the Theoretical Model of Gardening Behaviour

For further analysis, we calculated variable indices as averages of indicators for all variables except for gardening behaviour before or after COVID-19. In these two cases indices were calculated as the sum of activities. The Shapiro-Wilk test showed that none of the variables were normally distributed. To verify the relationships between self-perception of behavioural changes and both types of fear and age, we calculated Spearman's correlation coefficients and statistical characteristics of the relationships (Figure 7). The self-perceived gardening changes variable could be assumed to be close to a type. We, therefore, calculated the logistic regression analysis to gain an additional insight into potential partial regression coefficients which could not be identified with the Spearman correlation coefficients.

The theoretical model of correlations seemed to operate well as almost all the hypothesised variables showed a statistically significant Pearson correlation (full lines within the Figure 7). Gardening behaviour before and during the crisis could be explained by food security concerns, both future food concerns and during the COVID-19 crisis, and by gardening attitudes, both positive and negative. The logistic regression analysis (standardised beta coefficients) confirmed the results of the Spearman correlation in all cases except the correlation between gardening behaviour before COVID-19 crisis and self-perceived gardening changes during COVID-19. Here we saw no statistical correlation, meaning that COVID-19 did not spur those that were already active gardeners more than those who had not yet gardened before.

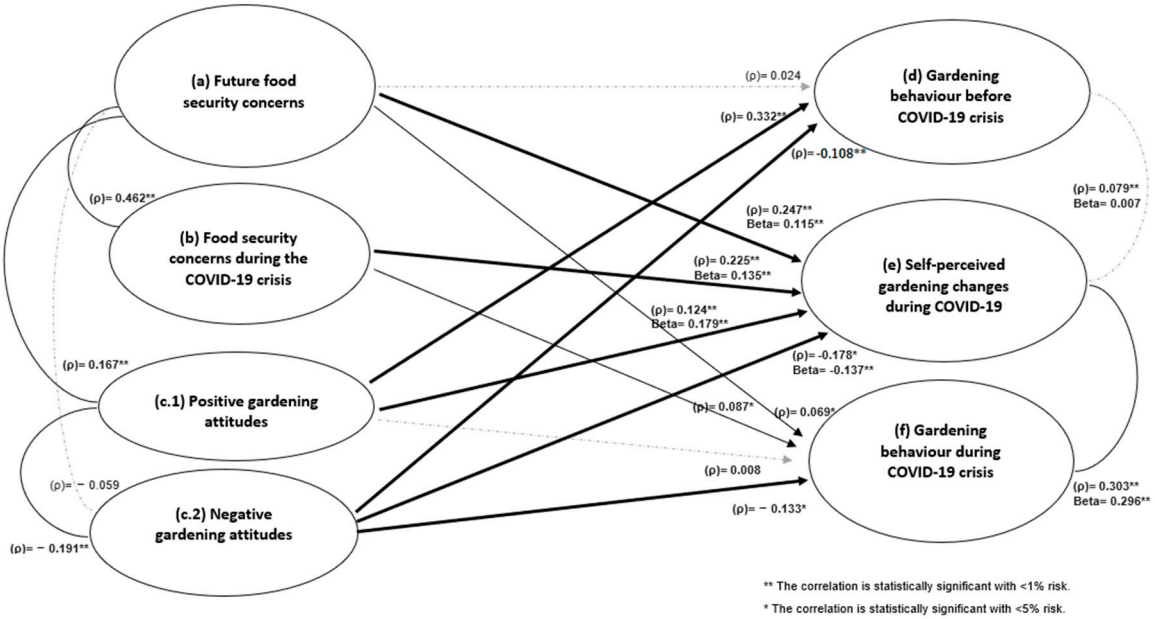

Figure 7. Analysis of socio-psychological variable correlations: reported are the Spearman correlation coefficients and the statistical significance of correlations (the thickness of arrows reflects the strength and significance of correlations). For self-perceived gardening changes during COVID-19 we report also standardised Beta coefficients from the logistic regression analysis.

4. Discussion and Conclusions

While Lin et al. [72] provided one of the first analyses of the increase of interest in gardening during the early months of the COVID-19 pandemic, this is one of the first studies to provide an empirical analysis of the motivational drivers for the behavioural change. Both fear for general future food security, and fear for food security during COVID-19, were shown to have a strong correlation to home gardening during COVID-19, impacting self-perceived and actual behaviour changes.

This is in line with postulates of the Protection Motivation Theory [60,61], which served as the basis for building the general model (Figures 1 and 7). It also confirmed that the components of fear, as defined by Rogers et al. [60], being the magnitude, the probability, and the efficacy of protected response, were present in the COVID-19 situation and triggered the attitude, and the behavioural change. Similar observations were made by other studies in contexts other than gardening, such as health protective measures [73], consumer behavioural change [74] and vaccination intentions [75], among others.

Measured as loose as introducing at least one new gardening activity during COVID-19, this study found a 10% rise in home gardening during the first wave of COVID-19 during 2020 (in a sample skewed towards educated, female and middle-class participants). Only education and size of residence seemed to correlate with COVID-19 induced changes in gardening behaviour, while we did not find any effect in terms of age and gender on home gardening behaviour. This negated any potential stereotypes of home gardeners as being predominantly female and older.

Local gardening cooperatives were shown to be a relatively small sample (5.3% before with 0.6 increase after). However, compared to results by Chenarides et al. [47], these results did not show a decrease in community gardening due to the pandemic, but rather a slight increase. The highest reason for the participants not to be interested in home gardening seemed to be the fact that they were provided with produce from friends/family who were gardening. This is in line with research conducted in the Czech Republic that showed that 38% of households produce some food in either a garden or an allotment, and nearly two-thirds (64%) of these (one-quarter of all Czech households) give some of their produce

to others [11]. Sovová et. al. [12] state that this represents a specific ethics of care, embodied in sharing of home-produced food with others.

Analysis of differences according to education showed that while home gardening was more common amongst participants with lower levels of education before the pandemic, it was participants with higher education that reported a larger impact of the pandemic on their home gardening interest and uptake of new gardening activities. The results are similar to Chenarides et al. [47], who noted that during the pandemic home gardening was practiced by younger and more educated households.

Similarly, it was the urban participants who reported higher impact of the pandemic on their home gardening interests, although the answers about specific gardening activities did not confirm the urban–rural divide in the actual home gardening uptake. However, this discrepancy might be due to the differences in actual possibilities for home gardening in urban areas and showed a need for further development of urban farming. On average, respondents were only moderately concerned about future food security, and mostly estimated their own risk to be lower than that of other people. The results, thus, reflect the so-called optimism bias [70]. The participants did not perceive home gardening as a highly effective means to save money. Though it would be important to follow the development of this attitude with the current trend of increasing food prices after the pandemic and with the war in Ukraine.

It is important to note that this research showed for the first time the extent of aquaponics as a relatively new form of home gardening in Europe. Elsewhere, we have claimed that aquaponics has been spurred to a large extent by DIY enthusiasts [71] in Europe. However, there is a lack of data to show the extent of the DIY interest among home gardeners. Although unrepresentative of the population, this sample showed for the first time an approximation of the extent of aquaponics in relation to other forms of home gardening. It is amongst the least common forms: 2.6% is less than 30 participants from 1000. This, on the one hand, shows that aquaponics continues to be a niche in the European home gardening sector with a small rate of innovation adoption. On the other hand, it shows that a small group of home gardeners are willing to approach home gardening with such a novel approach.

On the other hand, there was no statistically significant correlation between gardening behaviour before the pandemic and future food security concerns. Rather, gardening before the pandemic was correlated with attitudes about gardening, such as perceiving benefits for one's health and wellbeing or requiring too much knowledge or other resources. Thus, most importantly, this study shows that the pandemic did trigger an important psychological push towards home gardening as predicted based on Protection Motivation Theory.

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Appendix A

Table A1. Self-perceived gardening changes during COVID-19. Cronbach's alpha was 0. 599; factor analysis explained 54.84% of the total variance.

Statement	Average	STD	Factor Component: Self-Perceived Gardening Changes during COVID-19
I have started to think more about the possibilities of home gardening during the COVID-19 pandemic.	3.33	1.50	0.843
I have taken steps toward home gardening during the COVID-19 pandemic.	4.07	1.34	0.834
COVID-19 did not cause any changes in my home gardening plans since I already was a very active home gardener even before the crisis.	2.60	1.54	−0.488
Average (n_{valid} = 1035)	2.41	1.07	

Table A2. Analysis of differences between the groups (education, social class, population's size of place of residence, gender) for three aspects of gardening behaviour. The differences were assessed with non-parametric tests (Kruskal-Wallis and Mann-Whitney U Test for independent samples). Reported are significances of differences between groups. For the variable "age", Spearman correlation was analysed.

	Kruskal-Wallis Test, Asymp. Sig.			Mann-Whitney U Test for Independent Samples, Sig.	Spearman Correlation Coefficients, Sig.
	Education	Social Class	Population Size of Place of Residence	Gender	Age
Gardening behaviour before COVID-19	0.016 *	0.046 *	0.000 **	0.555	-
Self-perceived gardening changes during COVID-19	0.006 *	0.169	0.000 **	0.142	−0.023
Gardening behaviour during COVID-19	0.050 *	0.648	0.377	0.080	-

** The correlation is statistically significant with <1% risk. * Correlation is statistically significant with <5% risk.

Table A3. Future food security concerns, Cronbach's alpha was 0.778; factor analysis explained 54.31% of the total variance.

Statement	Average	STD	Factor Component: Future Food Security Concerns
Food insecurity poses the greatest threat to humanity in the near future.	2.42	1.19	0.524
In the country where I currently reside, people in crisis situations like those at the time of the COVID-19 epidemic will be at serious nutritional risk.	1.19	1.22	0.674
It is very likely that my loved ones will not have access to quality and healthy food in future crises like the COVID-19 crisis.	1.29	1.14	0.849

Table A3. *Cont.*

Statement	Average	STD	Factor Component: Future Food Security Concerns
It is very likely that I myself will be left without quality and healthy food in future crises like the COVID-19 crisis.	1.14	1.11	0.837
I myself am in danger of not having enough quality and healthy food in the future.	0.99	1.13	0.751
Average (n_{valid} = 931)	1.4	0.84	

Likert scale, 1 = strongly disagree, 5 = strongly agree; Extraction method: Principal component analysis.

Table A4. Concerns about of food security during the COVID-19 crisis, Cronbach's alpha was 0.785; factor analysis explained 51.09% of total variance.

Statement	Average	STD	Factor Component: Food Security Concerns during the COVID-19 Crisis
During the past few months, I have worried about how easy it will be to buy fresh fruits and vegetables.	1.43	1.32	0.702
I believe that my area has been shown to have the best food stores, even at the time of the COVID-19 crisis. (recoded)	1.23	1.19	0.561
I was afraid that my local food stores would be selling outdated or rotten fruit and vegetables.	0.76	1.06	0.658
At the time of the COVID-19 crisis I never had to worry about how easy it would be to buy fruit and vegetables. (recoded)	1.26	1.31	0.788
I have not worried at all as to where I would get/buy fruit and vegetables during the COVID-19 crisis. There was, and still is, enough good quality produce available. (recoded)	1.06	1.19	0.833
Average (n_{valid} = 1035)	1.15	0.86	

Likert scale, 1 = strongly disagree, 5 = strongly agree; Extraction method: Principal component analysis.

Table A5. Gardening attitudes. Cronbach's alpha was 0.631; factor analysis explained 64.9% of the total variance.

Statement	Average	Standard Deviation	Factor Analysis	
			Component 1: Positive Gardening Attitudes (38.28% Variance)	Component 2: Negative Gardening Attitudes (16.15% Variance)
By setting up my own garden, I prevent the danger of food insecurity in the future.	2.21	1.26	0.680	0.332
Home gardening is an effective method for me to prevent my future food insecurity.	2.19	1.20	0.718	0.424
Home gardening relaxes me and, in this way, is an effective way for me to stay healthy.	2.05	1.22	0.576	0.565
Home gardening keeps me fit.	2.28	1.27	0.543	0.577

Table A5. *Cont.*

Statement	Average	Standard Deviation	Factor Analysis	
			Component 1: Positive Gardening Attitudes (38.28% Variance)	Component 2: Negative Gardening Attitudes (16.15% Variance)
Home gardening enables me to save more money, when buying food, because I produce some food by myself.	2.43	1.28	0.657	0.299
Average (n_{valid} = 924)	2.19	0.95		
I do not have the means (space, money, time) for a home garden. (* rec)	2.95	1.63	−0.508	0.565
I do not have the necessary theoretical knowledge and/or practical experience for home gardening. (* rec)	2.97	1.50	−0.590	0.603
I am not interested in home gardening at all. I buy all the food I need. (* rec)	3.06	1.68	−0.620	0.622
I am not interested in home gardening, because my relatives and/or neighbours and/or friends, who have their own garden, supply me with surpluses of fresh vegetables and/or fruits they produce. (* rec)	2.70	1.65	−0.690	0.487
Average (n_{valid} = 975)	2.92	1.33		

Likert scale, 1 = strongly disagree, 5 = strongly agree; Extraction method: Principal component analysis. * rec = reverse recoded.

Table A6. Analysis of differences between the groups (Education, Social class, Population's size of place of residence, Gender). The differences were assessed with non-parametric tests (Kruskal-Wallis and Mann-Whitney U Test for independent samples. Reported are significances. For the variable age, Spearman correlation was analysed.

	Kruskal-Wallis Test, Asymp. Sig.			Mann-Whitney U Test for Independent Samples, Sig.	Spearman Correlation
	Education	Social Class	Population size of Place of Residence	Gender	Age
Future food security concerns	0.595	0.623	0.115	0.080	0.087 **
Food security concerns during COVID-19	0.404	0.375	0.069	0.203	−0.032
Positive gardening attitudes	0.000 **	0.000 **	0.000 **	0.000 **	0.116 **
Negative gardening attitudes	0.000 **	0.384	0.000 **	0.216	−0.072 *

** The correlation is statistically significant with <1% risk. * Correlation is statistically significant with <5% risk.

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