

## Article

# Sex Differences in Spatial Activity and Anxiety Levels in the COVID-19 Pandemic from Evolutionary Perspective

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**Abstract:** Despite the enforced lockdown regime in late March 2020 in Russia, the phenomenon of the continued virus spreading highlighted the importance of studies investigating the range of biosocial attributes and spectrum of individual motivations underlying the permanent presence of the substantial level of spatial activity. For this matter, we conducted a set of surveys between March and June 2020 (N = 492). We found that an individual's health attitude is the most consistent factor explaining mobility differences. However, our data suggested that wariness largely determines adequate health attitudes; hence, a higher level of wariness indirectly reduced individual mobility. Comparative analysis revealed the critical biosocial differences between the two sexes, potentially rooted in the human evolutionary past. Females were predisposed to express more wariness in the face of new environmental risks; therefore, they minimize their mobility and outdoor contacts. In contrast to them, the general level of spatial activity reported by males was significantly higher. Wariness in the males' sample was less associated with the novel virus threat, but to a great extent, it was predicted by the potential economic losses variable. These findings correspond to the evolutionary predictions of sexual specialization and the division of family roles.



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**Keywords:** pandemic; sexual selection; spatial activity; risk-taking behavior; anxiety; health attitude

## 1. Introduction

Human spatial activity and daily dynamics of an individual's mobility have obtained unprecedented importance in the COVID-19 pandemic. Nowadays, human spatial activity and related motor activity are the basis of urban life, which forms the space and environment of modern humans. The study of spatial activity can give us important information about a wide range of socio-economic phenomena and expand our understanding of human behavior in the context of its interaction with the modern highly urbanized environment both in periods of stability and in periods of critical environmental changes, including the emergence of a new infectious disease. The biosocial response to threats associated with new viral infections involves major changes in individual mobility. Individual choices on how to react to a coronavirus threat during the 2020 pandemic (to follow or to violated the official instructions) shape the course of the virus's spread and the risks facing human populations. For instance, reducing spatial activity, increasing interpersonal distance during communication, and limiting contacts are mechanisms developed by evolution as a biosocial adaptation to new infectious diseases [1]. At the same time, quarantine procedures that were initialized by governments pursued social distancing, hence, reducing individual contacts and reducing the degree of physical activity related to daily and weekly spatial mobility. Concurrently, this public health emergency instructions was taking place in a media environment saturated with misinformation, partisan infighting, and messaging undermining health experts [2]. Despite the strict lockdown regime introduced in late March 2020 in most of the regions of Russia, the ongoing virus spreading highlighted the importance of investigating the range of biosocial and psychological attributes, which potentially could explain the models of the substantial level of spatial activity. Studies of

past epidemics and pandemics (Ebola 2014/2016, H1N1 2009/2010, avian influenza in 2006) have shown that a significant portion of the population is susceptible to anxiety, altering health attitudes related to the desire to protect themselves and their beloved during periods of active viral threats [3–6]. The novel COVID-19 coronavirus (SARS-CoV-2) pandemic has affected nearly every aspect of economic, social, and political life. The pandemic had become a significant source of psychological and physical stress for a considerable number of people all over the world due the attitude toward socioeconomic crisis triggered by COVID-19, social conflicts, exacerbated health-care systems, restrictions and fear of punishments by authorities, and other stress-related factors [7].

Introducing mandatory self-isolation measures imposes restrictions on a wide range of basic human needs, which are associated with the critical aspects of life-sustaining functions. For instance, spatial activity plays a crucial role in individual subsistence, initiating a multitude of processes related to resource acquisition, reproductive, environmental, and other biosocial tasks [8–11]. Currently we are witnessing substantial individual variations in knowledge and concern about COVID-19 and the willingness to change spatial behavior in the face of the pandemic. In a biological sense, the vital motivational stimuli associated with spatial and motor behavior that is directly affecting the distance of individual movement are an individual's fundamental needs in resource acquisition and in performing their reproductive functions and efforts [8,9]. At the same time, the evolution of monogamy in humans and strong pair-bonding assumes intensified male parental investment [10,11], with a certain degree of specialization of each sex within a pair. Men are more likely to provision material resources and income to the family budget, while women are more focused on the direct care of offspring. As it has been argued that, in human evolutionary past, males exceeded females in Euclidean spatial abilities, since they faced more significant navigational challenges, for reasons of either polygyny [12–14] or the navigational demands of prey hunting [15]. Spatial tasks other than navigation may also have undergone substantial selection pressure in males, particularly the demands in spatial target analysis and enhanced competitiveness in fighting to obtain resources [16]. This division of functional responsibilities in the family has been recorded in many traditional societies [17–21]. Spatial movements and activity patterns, for instance, the most likely distances and directions of the people's daily mobility, have been profoundly investigated in the contemporary societies [22–25]. The study of human mobility in urban China, for example, have shown that men's and women's average day travel distances were statistically different, with an expected daily distance for men of about 2 km, and lesser daily mobility for women. These findings support the hypothesis of evident sex differences in models of daily mobility in post-industrial societies [26].

The degree of daily mobility can be changed for both sexes in the periods of different environmental threats accompanied by a substantial growth of anxiety levels within a population. Numerous studies report that more than 50% of respondents experience a high level of anxiety during viral epidemics or pandemics [3,27], which leads to changes in various behavioral patterns including spatial activity. Adaptive response mechanisms to the environmental challenges differ for men and women of various sex-age groups.

Women are known to be more cautious and prone to avoid most types of risks as compared to men [28,29]. Slovic [30] has examined sex differences in risk perception in the health/safety domain. Male and female respondents differed significantly in their perception of all risk categories related to health and safety. Several studies where domain-specific risk was investigated confirmed that female respondents were less likely to be engaging in risky behaviors; they also perceived threats to a greater extent [31,32], especially in categories related to health and safety. Kruger with coauthors highlighted a specific evolutionary valid domain—environmental risks, possibly the most ancient domain, stemming from our ancestral history of foraging, hunting, and avoiding predators and parasites. They found that men were significantly more risk-taking than women in all evolutionary valid risk domains (such as between-group and within-group competition, mating and resource allocation for mate attraction and environmental risks) [33].

A number of studies investigated the relationship between anxiety and propensity to risk-taking behavior in different decision-making domains [34–37]. Various research have documented that individual differences in anxiety are associated with risk-avoidant decision-making. Maner with coauthors showed that individuals with high levels of all primary forms of anxiety (social stress, anxiety trait, and worry) and participants from an anxiety-disordered sample demonstrated a tendency to avoid risk in behavioral risk-taking tasks [38]. In several studies, sex differences in anxiety states were documented: women exhibit greater fear and are more likely to develop anxiety disorders than men. The sex differences are present in early childhood, increase during the next years, and continue through adolescence [39]. Similar differences exist in adult samples [40–42].

The influence of the age factor on the level of disease concerns changing the degree of spatial activity is expected; in particular, a propensity to risk-taking decision making reveals significant age differences. Risky behavior is most expressed in young people because selection pressure was ancestrally more significant for this demographic group than for any other age groups. Youth more than any other age group is engaged in risky behavior in various areas, including health risks [43]. As a result, young people could experience less wariness associated with the potential virus threat and are less likely to limit their movement activity. Thus, Jungmann and Witthöft, in their investigation of the factors related to coronavirus level of worry, have found that respondents belonging to the middle age category (30–59 years) differed from the younger (up to 30 years) age group in the direction of more significant level of anxiety [44].

The higher wariness in the different sex-age groups can also be related to the fear of economic losses: the responsibilities pressure on men in their middle ages is high; they need to care about providing for their less protected relatives—children, elderly parents, wives who do not have their own income. Thus, within different sex-age groups, spatial activity during the pandemic may differ. A rapid growth in economic anxiety has been documented worldwide since the beginning of the COVID-19 epidemic. Based on data collected in 194 countries, Fetzner with coauthors [45] found that beliefs about the high mortality from the coronavirus and its contagiousness were substantially positively associated with economic wariness. However, the reason for this association may be the individual level of anxiety and subjective beliefs about pandemic risks, which in particular depend on fundamental sex differences in level of worry.

The goal of this study was to analyze the sex differences in spatial mobility, level of worry and resource acquisition during the time of the first wave COVID-19 quarantine in urban samples from postindustrial societies.

## 2. Materials and Methods

### 2.1. Sample and Data

The current study included 490 participants (427 from Russia, 21 from Ukraine, 9 from Kazakhstan, 8 from Belarus, 4 from Germany, 2 from Poland, 2 from Switzerland, and 19 from other countries). Hence, the sample's distribution was highly diverse in terms of studied geographical regions and population density in place of individual residence. The Russian language was the only inclusion criterion for recruitment of participants saves the age that was supposed to be above 17 years old. The sample was gender-balanced (female  $N = 225$ ; males  $N = 265$ ) with the mean age of the participants being 35.49 ( $SD = 10.03$ ).

### 2.2. Procedures

Participants were recruited primarily via “Pickabu,” one of the most popular entertainment websites in the Russian-language segment of the Internet, which allow their users to aggregate social news via messages. In a set of public messaging potential participants were asked to take part in research devoted to coronavirus investigations and complete the online survey about their spatial activity and mobility during the pandemic. Recruitment did not offer any compensation. Participants provided informed consent and completed

the questionnaires via secure data collection software. All research participants received unique subject IDs that do not identify them as individuals.

The study took place from 29 March 2020 to 27 June 2020 (Median 12-APR-2020), during the virus outbreak in Russia accompanied by an obligatory strict quarantine regime.

### 2.3. Field Measurements

In this study, we implemented a preregistered self-report questionnaire suitable for measuring the mobility and spatial behavior during the pandemic COVID-19. We focused on examining the one-factor structure of the three items that constitute the individual spatial behavior. A latent variable was manifested within three items: (1) weekly most distant place from home as the measure of elapsed time in minutes required to get to that place, (2) daily most distant place from home in minutes, and (3) the number of trips away from home during last week. The reliability of these three items was assessed by exploratory factor analysis with a Cronbach's alpha of 0.64, which may be classified as an acceptable level of reliability according to generally accepted rules.

The health attitude variable was obtained through the following item: "How do you assess the reliability of the threat posed by the new virus?" Participants were asked to rate the degree of danger that this new virus could have on a 10-point Likert scale.

Level of worry was determined by the question: "How do you feel about the current situation with the coronavirus COVID-19? Indicate the degree of your level of worry." Items were anchored on a 10-point Likert scale; participants responded by indicating the degree to which they agreed with the item description (from 1 "calm" to 10 "strong level of worry").

The question about the self-estimated level of the negative effect that could be imposed by quarantine restrictions on the family income—economic losses or negative impact of the household subsistence—was of particular interest. Participants were asked to rate the degree of economic losses that COVID-19 could impose, rated on a 10-point Likert scale.

The primary demographic attributes and items concerned a household structure were included in the survey. Descriptive statistics are presented in Tables 1 and 2 for males and females, respectively. Correlations between tested traits in the study sample are represented in Table 3.

**Table 1.** Descriptive statistics (Males).

Descriptive Statistics Males						
	N	Range	Min	Max	Mean	SD
Age	225	52	17	69	34.93	9.480
Family size	225	20	0	20	2.41	1.893
Children in a family	225	3	0	3	0.42	0.658
Level of worry	225	9	1	10	5.23	2.596
Health attitude (virus concern)	225	9	1	10	6.80	2.473
Economic losses level	225	9	1	10	4.53	3.229
Daily distance in minutes	221	120	0	120	17.59	22.540
Weekly activity level	225	10	0	10	5.61	3.309
Weekly distance in minutes	219	240.0	0	240.0	33.740	35.3020
N	217					

**Table 2.** Descriptive statistics (Females).

Descriptive Statistics Females						
	N	Range	Min	Max	Mean	SD
Age	265	51	18	69	36.02	10.444
Family size	263	8	0	8	2.60	1.324
Children in a family	263	3	0	3	0.44	0.662
Level of worry	264	9	1	10	6.19	2.338
Health attitude (virus concern)	264	9	1	10	7.17	2.383
Economic losses level	265	9	1	10	4.62	3.085
Daily distance in minutes	262	180	0	180	13.69	22.048
Weekly activity level	263	10	0	10	4.44	3.128
Weekly distance in minutes	262	180.0	0	180.0	32.178	33.3903
N	257					

**Table 3.** Correlations between tested traits in the study sample.

Correlation Matrix										
	Activity Arithmetic Mean	Age	Health Attitude (z-Score)	Level of Worry (z-Score)	Economic Losses (z-Score)	Sex	Marital Status	Family Size	Elderly People	Children
Activity Mean	1.000									
Age	−0.026	1.000								
Health attitude (z-score)	<b>−0.268</b>	0.060	1.000							
Level of worry (z-score)	<b>−0.135</b>	<b>0.134</b>	<b>0.519</b>	1.000						
Economic losses (z-score)	−0.011	0.064	0.066	<b>0.213</b>	1.000					
Sex	<b>−0.126</b>	0.054	0.075	<b>0.192</b>	0.014	1.000				
Marital status	0.006	<b>0.155</b>	0.001	0.208	<b>0.112</b>	0.049	1.000			
Family size	0.038	<b>0.120</b>	0.038	<b>0.146</b>	<b>0.110</b>	0.058	<b>0.300</b>	1.000		
Elderly people	−0.018	<b>0.168</b>	−0.028	0.030	<b>−0.137</b>	−0.007	<b>−0.118</b>	<b>0.194</b>	1.000	
Children in a family	0.078	0.069	0.019	0.062	0.051	0.014	<b>0.322</b>	<b>0.513</b>	−0.018	1.000

Note. Bolded numbers are statistically significant with  $p$ -values  $< 0.05$ ;  $N = 490$ ; Activity level ( $M = 0.0027$ ,  $SD = 2.287$ ) represents an arithmetic mean of three z-transformed parameters: (1) weekly activity level, where  $M = 33.18$  (minutes),  $SD = 34.4857$ ; (2) daily activity level, where  $M = 15.74$  (minutes),  $SD = 22.816$ ; (3) a number of trips out of home during last week with  $M = 5$  times per week and  $SD = 3.2685$ ; Age of respondent  $M = 35.49$ ,  $SD = 10.03$ ; Health attitude  $M = 6.9918$ ,  $SD = 2.4395$ ; Level of worry  $M = 5.7393$ ,  $SD = 2.508$ ; Economic losses  $M = 4.5691$ ,  $SD = 3.147$ ; Sex of respondent: males  $N = 225$  and females  $N = 265$ ; Marital status with two parameters (1) “Cohabit with a partner” ( $N = 286$ ); “Single” ( $N = 206$ ); Family size Min = 0, Max = 20 with  $M = 2.51$ ,  $SD = 1.612$ ; Presence of elderly people in the household with two parameters “Yes” ( $N = 63$ ) and “No” ( $N = 427$ ); Number of children in a family  $M = 0.43$ ,  $SD = 0.659$ .

#### 2.4. Statistical Analysis

Statistical analysis was performed using SPSS statistical software (IBM Corp) and via R statistical programming environment. Here we used the lavaan package [46] for R. The analyses give readers an in-depth look at the relationships between the key variables highlighting the effects in regression in the structural equation modeling (SEM) framework. Structural equation modeling (SEM) is among the fastest growing statistical techniques in evolutionary psychology and ecology. It provides a new way to explore and quantify relationships in diversity of systems with numbers of predictors and responses with complex causal connections. SEM unites multiple variables in a single causal network, thereby allowing simultaneous tests of multiple hypotheses. The idea of causality is central to SEM as the technique implicitly assumes that the relationships among variables represent causal links. Because variables can be both predictors and responses, SEM is also

a useful tool for quantifying both direct and indirect (cascading) effects. The structural model displays the interrelations among latent constructs and observable variables in the proposed model as a succession of structural equations—akin to running several regression equations. In traditional SEM, the relationships among variables (i.e., their linear coefficients) are estimated simultaneously in a single variance-covariance matrix.

### 3. Results

#### 3.1. The Structural Model

Preliminary analyses (Table 3) demonstrated that individual mobility (spatial activity level) is neither significantly associated with the age of the respondent, nor with the number of children in a family, nor with the presence of elderly people within the household. It has not revealed any correlation with the individual marital status. We could not find any impact of economic losses on the individual level of spatial activity and mobility.

The most consistent predictor of the observed range in variation of activity level demonstrated in our study was a health attitude variable. The latter variable reflects individual coronavirus perception, subjective beliefs about pandemic risks and understanding of the threat of a new virus.

Simultaneously, the health attitude had a profound association with the reported level of worry, which assumes that the anxiety state significantly impacted the personal response in the health attitude parameter.

To represent the casual relationships between the health attitude, level of worry reported by the respondents, and the scope of examined predictors, we performed the structural modeling in the lavaan package in R, which enabled us to represent the theoretical predictions of the relationship between the studied factors within one model.

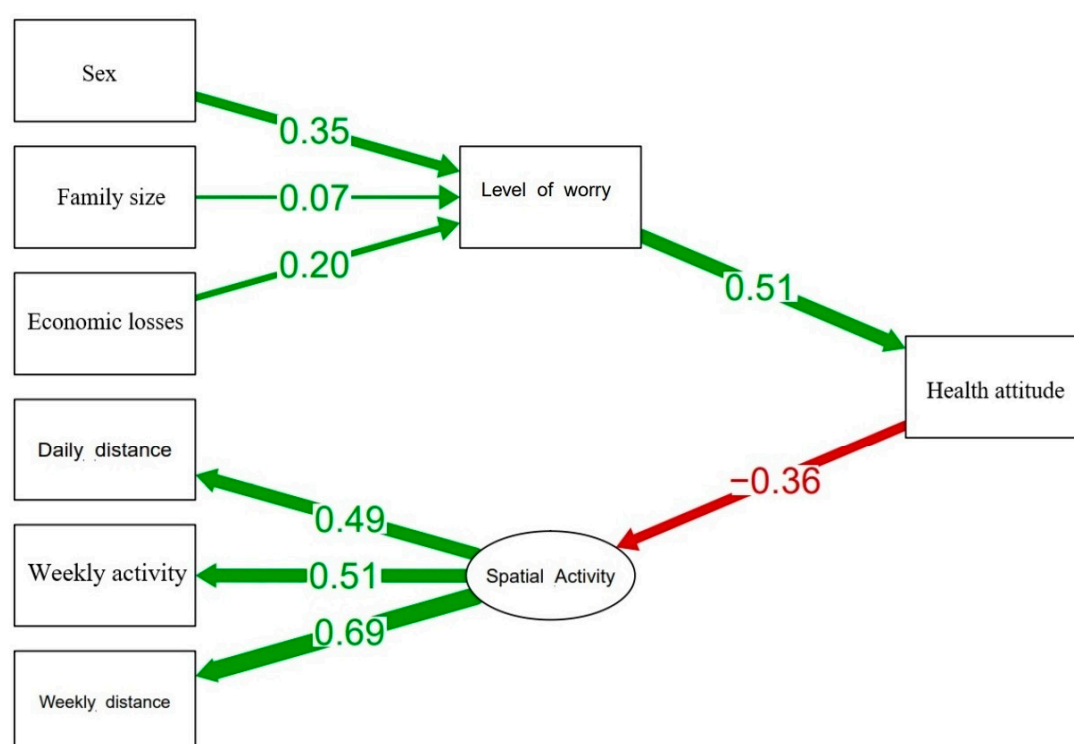
Table 4 shows the causal structure of the model's pathways with the parameter estimates included in the model and the model indexes. All pathways in the current model appeared to be significant; pathways with lower significance levels were removed from the model (Figure 1).

**Table 4.** SEM Individual activity in a pandemic.

Pathway		Estimate	Std. Estimate	SE	Critical Ratio	<i>p</i>
Activity	→Weekly distance	0.688	0.736	0.059	11.594	0.000 **
	→Weekly activity	0.508	0.538	0.053	9.539	0.000 **
	→Daily distance	0.487	0.525	0.052	9.428	0.000 **
Activity ←Health attitude		−0.355	−0.335	0.061	−5.817	0.000 **
Health attitude ←Level of worry		0.513	0.510	0.040	12.912	0.000 **
Level of worry	←Economic losses	0.196	0.197	0.044	4.475	0.000 **
	←Sex	0.346	0.173	0.088	3.945	0.000 **
	←Family size	0.074	0.121	0.027	2.740	0.006 **

**Note.** Model  $\chi^2$  was 20.858,  $df = 20$ ,  $p < 0.406$ . Significant paths with  $p$ -value  $\geq 0.001$  denotes by sign \*\*. The root mean square error of approximation (RMSEA) was 0.010; with Comparative Fit Index (CFI) = 0.998; Tucker-Lewis Index (TLI) = 0.997. R-Square: Weekly distance = 0.54; Weekly activity = 0.289; Daily distance = 0.276; Health attitude = 0.260; Level of worry = 0.092; Spatial Activity = 0.112.





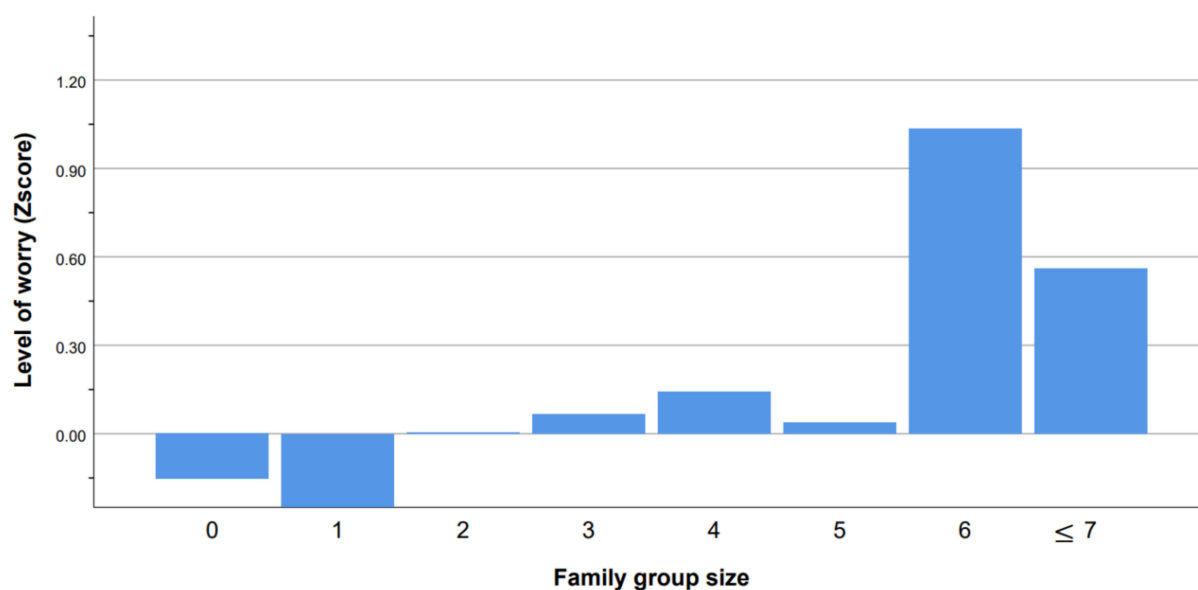
**Figure 1.** SEM. Individual activity in a pandemic. **Note.** The ellipse represents a factor “Spatial activity” with three indicators and is also called latent variable, constructs, or unobserved variable. Rectangles represent measured variables. A line with one arrow represents a hypothesized direct relationship between two variables. The strength of the association between variables is defined by arrow thickness. Negative relationships have pessimistic parameter estimates characterized by red arrows and positive relationships by green color.

According to our results, the most consistent predictor of the spatial activity or individual mobility was an adequate health attitude, which means that the individual level of subjective beliefs about pandemic risks and the understanding of the threat of the new coronavirus disease was crucial for decision-making about the spatial activity pattern. Our data suggest that activity levels have a causal relationship with the variable “health attitude,” and 36% of the individual spatial behavior variation could be explained by the personal concern of the potential virus threat. A higher level of concern about the virus threat significantly minimizes the individual level of spatial activity.

In turn, our model revealed that a health attitude pattern is positively associated with individual level of worry (Estimates = 0.513;  $z$ -value = 12.912;  $P(> |z|) < 0.001$ ).

In the next casual pathways, we demonstrated that the level of worry was significantly associated with sex (Estimates = 0.345;  $z$ -value = 3.954;  $P(> |z|) < 0.001$ ), in that females reported a higher level of wariness in a context of the COVID-19 pandemic. Economic losses (Estimates = 0.196;  $z$ -value = 4.475;  $P(> |z|) < 0.001$ ) had a notable impact on the wariness, and finally, family size also showed a significant positive association (Estimates = 0.073;  $z$ -value = 2.740;  $P(> |z|) = 0.006$ ).

We did not find any significant associations between the three dependent variables—(1) activity, (2) health attitude, and (3) anxiety level—and the presence of family members vulnerable to COVID-19: children or elderly people. However, a total number of individuals in a household was a significant factor, that increased the personal concern about the virus. We suppose this association was due to the higher probability of being infected by the COVID-19 within a larger family, or in a place of co-residence of several people, given that the higher number of inhabitants could affect the community’s health, and increase the respiratory infection rate among flat-dwellers. Figure 2 reveals the significant positive increase of anxiety with the increase of family size (or with the increase of the number of co-habitants) in a place of residence.



**Figure 2.** Number of inhabitants in a place of residence and the mean level of anxiety (z-score).

### 3.2. Sex-Specific Differences in the Multi-Sample SEMs Model Parameters

Given that the full group model may mask the effects specific to each sex, the multiple group model has been implemented. A detected non-invariance in the model intercepts (Chi-Squared difference  $p(\chi^2) < 0.00305$ ) and partly non-significant pathways represent the evidence in favor of systematic sex-specific differences in the model parameters being examined. We performed two SEMs separately for each sex. Figures 3 and 4 demonstrate the path diagrams for the males' (panel A) and the females' (Panel B) sample.



**Figure 3.** Panel A: SEM for males (N = 213).



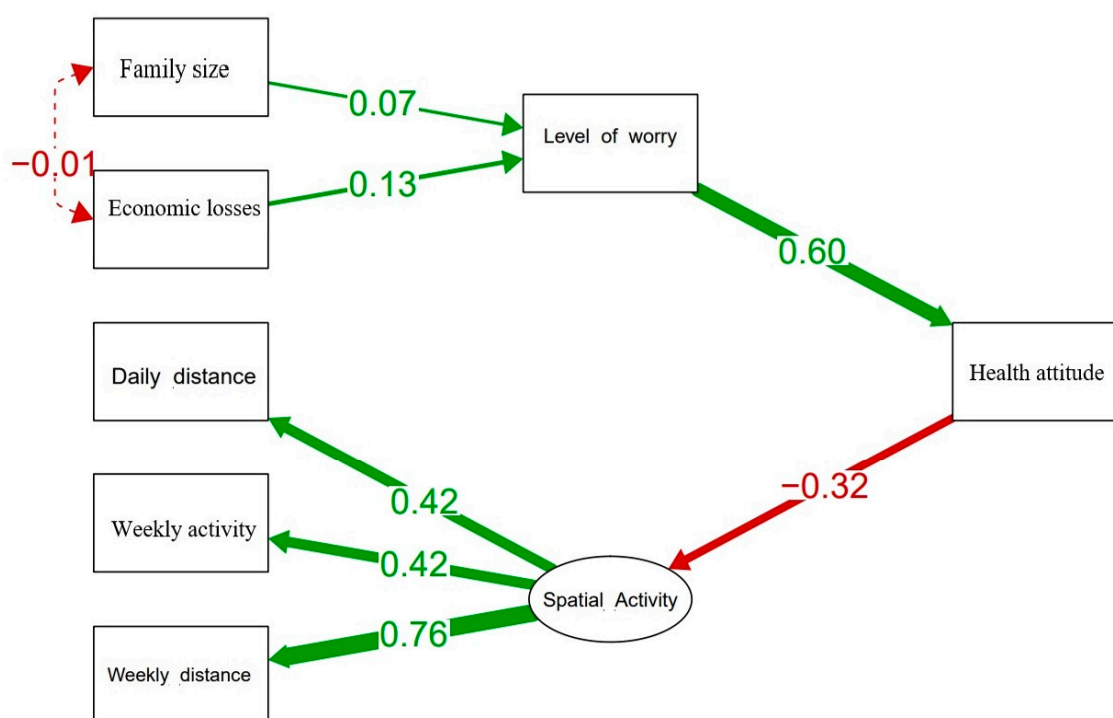
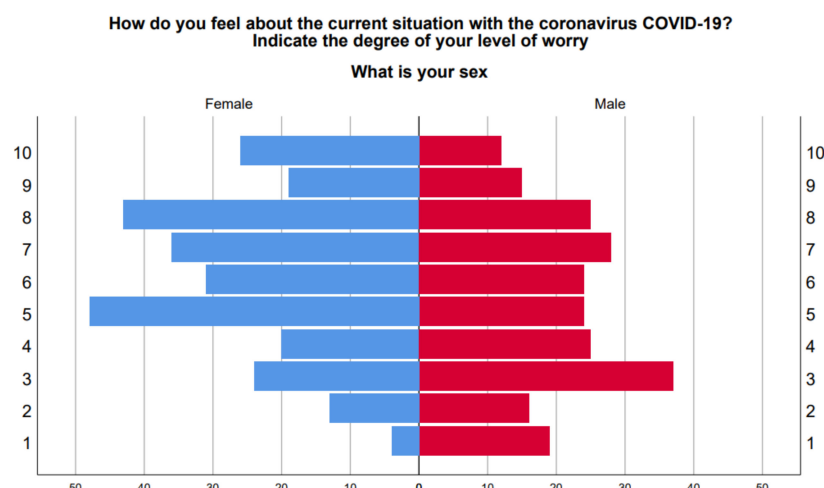


Figure 4. Panel B: SEM females (N = 252).

To operationalize the differences between the two sexes in our models, a system of orthogonal contrasts has been introduced. By comparing the magnitudes and direction of the interactions to those of the main sex-specific effects, we demonstrated the strong negative predictive reliance of the health attitude (understanding of the threat) to the activity level for both sexes; however, male activity was significantly higher than female activity ( $B = 16$ ,  $p = 0.019886$ ,  $t\text{-value} = 2.337$ ). We also detected that the level of anxiety in males was lower ( $B = 32$ ,  $p = 0.0623$ ,  $t\text{-value} = -1.869$ ). Hence, for the male sample, wariness was a less important factor in forming the adequate health attitude.

Observed differences—a level of wariness—also demonstrated more generous contributions into the level of concern about the virus threat in females (Male: Parameter Estimate = 0.439,  $P(>|z| < 0.001)$ ,  $z\text{-value} = 7.36$ ); Female: Parameter Estimate = 0.598,  $P(>|z| < 0.001)$ ,  $z\text{-value} = 11.007$ ).

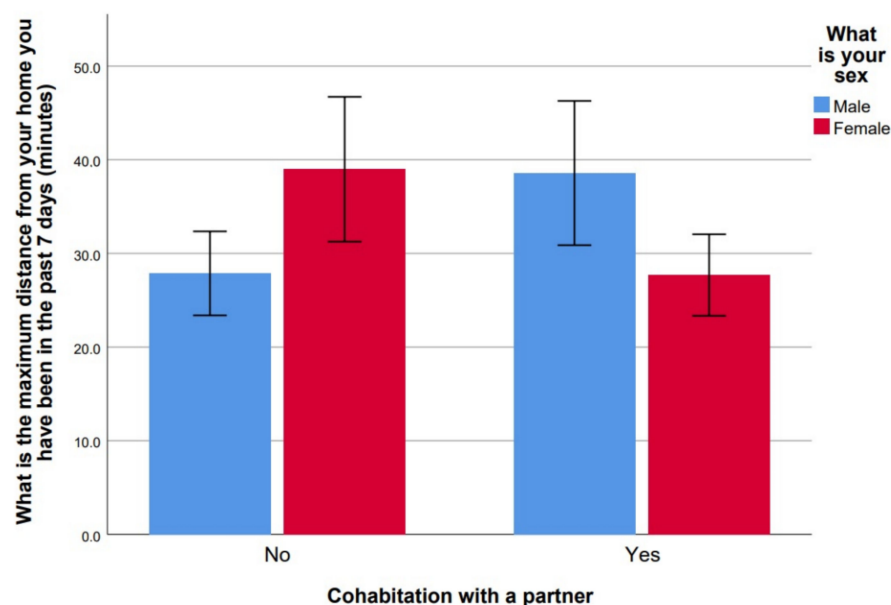
In both groups (males and females), the causality pathways from the level of worry to the health attitude are highly significant with major parameter estimates, suggesting the leading role of anxiety in resulting health attitude parameters (Figure 5). More than a half (252 out of 592 scored 6 and over, min = 1, max = 10, Mean = 5.74, SD = 2.5) of the respondents reported moderate to severe wariness and anxiety states associated with COVID-19, which made it possible to include this variable into a set of the main factors indirectly affecting spatial activity.



**Figure 5.** The level of worry in the sample: a distribution of answers for males and females.

### 3.3. Sex Differences in Mobility and Potential Explanation in a Family Role of Men and Women

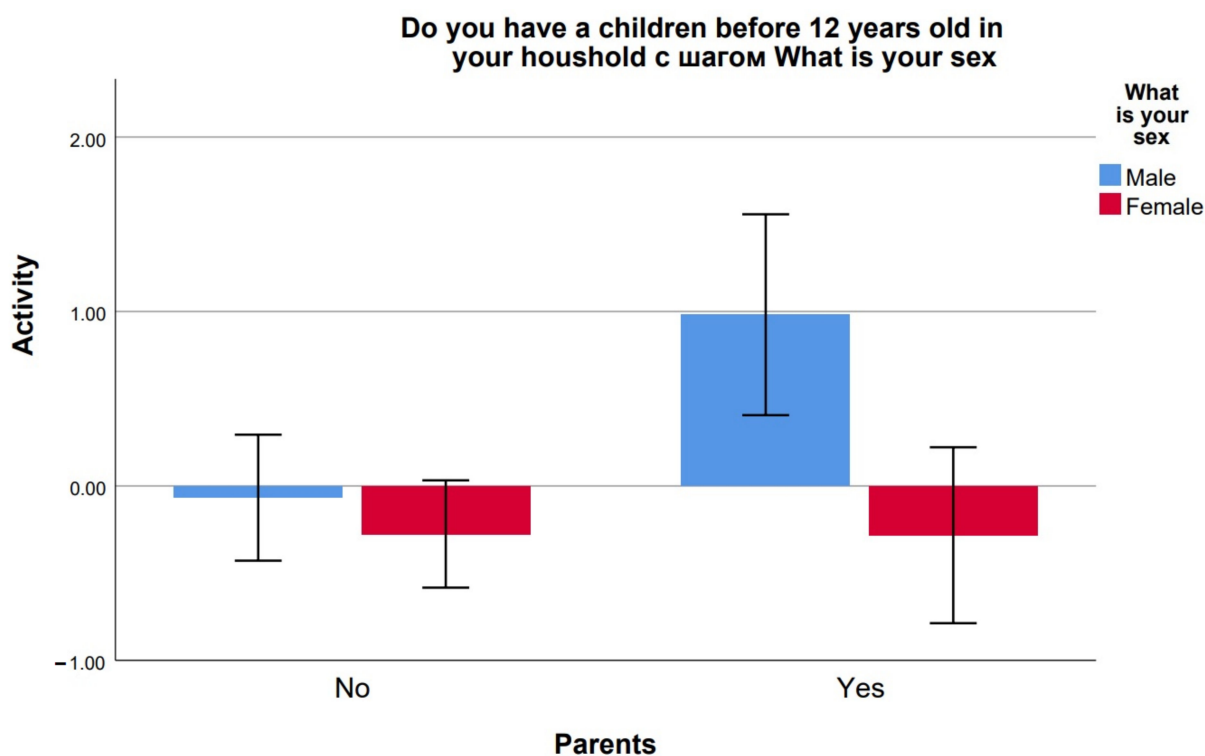
To investigate the potential cues and premises underlining the sex dimorphism in spatial activity, additional testing was implemented. The results suggested significant differences between the individuals with partners and singles for both sex (Figure 6). Females with a partners reported less spatial activity during the previous 7 days of quarantine ( $F = 7.35$ ;  $p = 0.007$ ;  $N$  (co-habitation with a partner) = 158, with Mean = 27.69, SD = 2.2; CI 95% [23.34; 32.04], compared to females, living alone:  $N = 104$ , Mean = 38.99 (min distance), SD = 3.9, CI 95% [31.26; 46.72]; while males with a partner reported significantly higher level of spatial activity for the same period ( $F = 15.84$ ,  $p = 0.018$ ;  $N$  (co-habitation with a partner) = 120, with Mean = 38.58, SD = 3.89; CI 95% [30.88; 46.28], compared to singles  $N = 99$ , Mean = 27.87 (min distance), SD = 2.26, CI 95% [23.38; 32.35].



**Figure 6.** Difference in weekly spatial activity levels between the individuals with partners and singles (in males' and females' groups respectively) during the pandemic's quarantine.

The observed differences in mobility patterns in males and females in the context of the current (SARS-CoV-2) COVID-19 pandemic may be caused by the division of roles when partners of the opposite sex are cohabiting in the same house. Sex differences in spatial activity do increase once families have offspring. Figure 7 demonstrates the potential differences in activity levels between the individuals who have children younger than

12 years old and those who have not. The key differences were demonstrated for males (Figure 7). In households with children, males showed a significantly higher level of spatial activity.



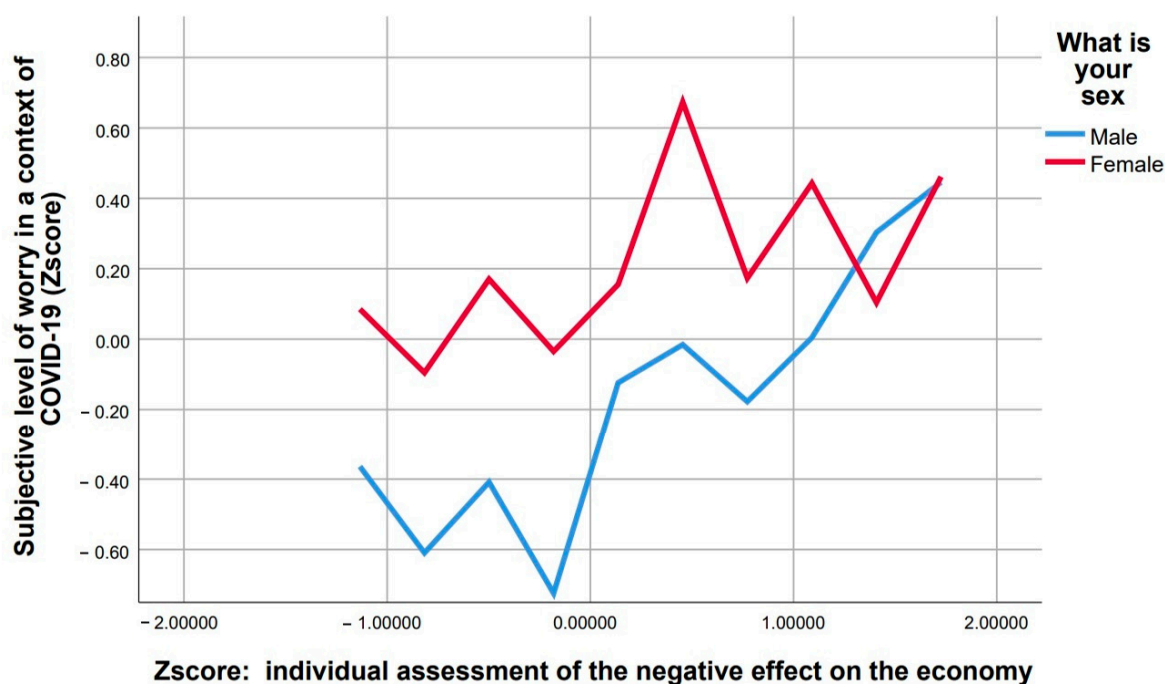
**Figure 7.** The difference in spatial activity levels (z-scores) between individuals who have kids and who do not (for male and female groups).

In both sexes, no significant association between the presence of elderly people in the household and the level of activity was found.

### 3.4. Economic Losses and Their Impact on the Level of Worry in Men and Women

One of the sufficient parameters affecting the level of wariness could have sociological and economic issues: an economic losses and potential negative effect on the economic stability of the household could directly affect the general level of wariness and anxiety, which became more obvious in the males' sample (Male: Parameter Estimate = 0.267,  $P(>|z|) < 0.001$ , z-value = 4.037); Female: Parameter Estimate = 0.132,  $P(>|z|) = 0.002$ , z-value = 2.270).

Figure 8 represents a growing trend of the marginal means values of the subjective level of worry in a context of COVID-19 for males' and females' samples that positively corresponds to the individual assessment of the negative effect on the economy.



**Figure 8.** Negative economic outcomes and their impact on the level of anxiety for males and females, respectively. Both variables z-transformed.

#### 4. Discussion

In this paper, we examined a link between several critical biosocial and socioeconomic parameters and personal mobility or spatial activity of Russian-speaking Internet users in the current COVID-19 pandemic context. We tested the effect of sex, age, household size and structure, economic losses, perceived virus threat, and wariness associated with the new COVID-19 virus. We did not find any association between the level of activity and the presence of elderly people in the households neither in men nor in women. Hence, our data supports the paternal investment hypothesis: altruistic intentions and a growth in spatial activity in adult males mostly took place in cases of children presence in the households, rather than the elderly people—who are the most vulnerable part of society.

The important finding is that the general level of spatial activity was sex-specific: males reported a significantly higher mobility level during the pandemic than females. These data are in agreement with previous studies on the sex differences in spatial activity and mobility, particularly, the overall higher level of general spatial activity in males [26,47]. These sex differences seem to be robust, assuming that men are utilizing larger territories than women across a broad spectrum of geographical and subsistence contexts [14,48,49]. Besides this, males outperform women in some spatial and navigational tasks [15,50]. Although the sex differences in spatial perception have been small, around half a standard deviation [51,52], they were demonstrated cross-culturally and have been found also in post-industrial societies. It is assumed that sexual dimorphism in spatial activity in contemporary societies may be a marker of social and economic inequality [26], biological predispositions, and sex-specific reproductive strategies [12,13,47].

In this paper, we highlighted that observed sex differences in spatial behavior potentially had been predefined by increasing females' avoidance of any risks associated with social contacts within a dangerous environment in the context of the COVID-19 pandemic. Several studies where domain-specific risk has been investigated confirmed that females were less likely to engage in risky behavior with stronger reaction on a threat, especially in the health/safety context of decision making [28–31]. Kruger with coauthors identified five risk-taking domains that reflect recurrent survival and reproductive challenges that humans have faced during our evolutionary history. This domain-specific scale includes

the risks associated with environmental challenges, such as a significant risk of mortality from predators, accidents, and parasites. In all these evolutionarily important areas of risk-related decision making, men showed a significantly higher propensity to risk-taking decisions than women, except one environmental risk domain in one study (where female respondents were more likely to take risks to save their infants [33]). Slovic [30] examined sex differences in risk perception in the health/safety domain and found sex differences in the perception of all risk categories related to health and safety. Similar results were recently obtained for the Russian sample [53].

According to our study, women revealed a higher level of wariness associated with the new viral threat, as was anticipated. Numerous studies describe sex differences in the endocrine, behavioral, and neural aspects of stress response. Women are much more susceptible to anxiety disorders, including stress-related major depressive disorders [41,54–59]. McLean and Anderson revealed that women exhibit greater fear and are more likely to develop anxiety disorders than men [41]. Our findings are consistent with data obtained by other scholars [60–63]. Jungmann and Witthöft recently investigated the impact of the coronavirus pandemic on anxiety levels in the German sample, and demonstrated that women reported substantially higher viral anxiety [44].

In the pandemic context, a higher level of anxiety among females followed by a reduction in their mobility as a risk-avoiding behavior is consistent with the theoretical principles of evolutionary biology, predicting differences in natural selection strength imposed upon males and females. We suggest that the notable reduction of any form of spatial activity in females may be due to mechanisms associated with the increase in anxiety or wariness. A high level of anxiety and the avoidance of risky decisions that have been triggered by increased environmental threat may be highly adaptive for women in situations where men are acting as primary protectors and providers.

The sex differences found by us in spatial and risk-taking behavior may reflect evolutionary evolved adaptive strategies still relevant to modern post-industrial environments. Risky behavioral strategies of young men generally promote social status, resource control and marital competition, ultimately increasing reproductive success. At the same time, female risk-taking behavior reduces the chances of reproductive success [64,65].

On the other hand, the growing level of wariness and the concern about the threat posed by the virus in the males' sample has been primarily associated with financial problems and potential economic loss. Our findings support the theoretical predictions of sexual dimorphism in parental and reproductive roles of male to female in family [21,66]. Specialization in family roles related to spatial activity and mobility originated in our evolutionary past, when males faced more significant navigational challenges for resource acquisition, namely, during hunting [15,67]. The potential differences between the males' and the females' samples in their responses to the economic challenges provoked by the new coronavirus COVID-19 could be due to a greater involvement of males in household provisioning and resource contribution for family subsistence, which is still being observed in current Russian reality. However, the studies conducted in other countries provided similar information. Similar to our findings, in New Zealand, economic loss and the wellbeing gap was larger among men than women; males rated higher on feeling of anger (9% gap between men who experienced economic loss during lockdown vs. men who did not, compared to a 1% gap among women), and feelings of loneliness (7% gap for men vs. 2% gap for women) [68].

According to our results, under the challenging conditions of the COVID-19 pandemic, the division of sexual roles within Russia's families was highly consistent and robust. Men who reported that they cohabit with a partner demonstrated a greater level of weekly activity than single men. In contrast, females living with a spouse reported that the weekly activity level has been lower in comparison to females without a partner. The division of sex roles in terms of spatial activity was more evident in males with children under 12 years old. The general level of activity in males with kids was significantly higher when compared to childless males. Hence, we suggest that current male and female strategies

are basically reflecting the evolutionary stable strategies of sex roles within a family, related to resource acquisition and economic investments [10,21,69–71].

Another important finding of the current study was the critical role of the health attitude, manifested through concern about the virus threat, in maintaining the observed variability of spatial activity and individual mobility. We found that higher confidence in the reality of the virus threat significantly reduces spatial activity. Along with this, an adequate health attitude and understanding of the virus threat were positively associated with the level of worry (anxiety) in the context of the COVID-19 pandemic. The lower scores of wariness and anxiety were associated with neglecting the rules of self-isolation and denial of scientifically reliable information about the coronavirus (SARS-CoV-2) and its potential risks.

One of the main conclusions of this study is that a higher level of anxiety and a higher level of wariness may function as powerful psychological mechanism of prevention of virus spreading, due to a sufficient reduction of the individual spatial activity.

However, health concerns and anxiety associated with epidemics/pandemics may have broad negative psychological consequences (e.g., stress, depressive intrusive thoughts, avoidance, fear-increasing) and may be associated with ineffective or unfavorable preventive behavior and adverse longer-term consequences such as persistent pessimism [72–76]. In our study, more than a half of the respondents reported moderate to extreme wariness and anxiety associated with SARS-CoV-2. Other studies suggest that the current COVID-19 pandemic causes considerable psychological and physical stress, and provide comparative data: over 50% of respondents reported a significant growth of virus anxiety in recent months, especially among individuals with an elevated health anxiety trait [4,74,76–78].

## 5. Limitations and Future Agenda

Despite the enforced lockdown regime in late March 2020 in Russia, the phenomenon of the consistent and continued virus spreading highlighted the importance of studies investigating the individual motivations underlying permanent presence of the substantial level of spatial activity that facilitates interpersonal human contacts. The current survey was designed in a relatively short form and successfully introduced in March 2020. The initial goal of our survey was the identification and detection of the critical factors, potentially predisposing individual mobility and violation of enforced social restrictions. Along with the significant influence on spatial activity that the key biosocial attributes could have had such as sex, family structure, and age, the preliminary survey included a number of non-validated single-items: (1) a level of worry, (2) individual level of the economic anxiety (economic losses), and (3) a health attitude variable. As stated in the current paper, the final analyses revealed that these sociopsychological factors have been of unprecedented importance in canalizing human mobility patterns. However, dealing with single-item constructs, which have shown a profound relevance to the initial study's goals, is an essential limitation of the current study. For example, the level of worry—a single-item variable—could be potentially expanded and, in the future, include a wider range of stress-related factors such as the sense of lack of freedom, etc. Undeniably, these three sociopsychological factors represent more complex constructs than the single-item measures introduced at the beginning of the present research. These points require additional consideration in future studies. We also admit that our survey does not encompass all the sociopsychological factors potentially influencing mobility level during a pandemic. For instance, sufficient impact of the attitude toward restrictions and fear of punishments by authorities on the individual spatial mobility level could be expected.

At the same time, the current results may be treated as successful and novel in outlining the key components influencing human mobility during the pandemic. Our study highlighted the future work agenda, which is supposed to implement a multidisciplinary approach and focus on analyzing the most consistent factor explaining mobility differences—the level of concern about the virus threat. It is important to keep in mind that the deviation of the health attitude variable to a great extent is laying beyond the



scope of anxiety state and stress-related factors, which had been studied in this paper and well-documented within psychological and sociological literature in the past. The resulting single-item health attitude variable in this paper potentially embodies various psychological features such as coronavirus perceptions, subjective beliefs about pandemic risks, the understanding of the danger of a new virus, and even sustainability to the amplification of vast amounts of disinformation (misinformation) about COVID-19, in other words, to the “Infodemic” pressure. These questions stand beyond the tasks of current paper, represented evolutionary approach predominantly focused on sex differences.

The dramatic drop in offline field research availability during the lockdown regime and ultimately orientation on the online data collecting resulted in the essential shortage of the sample size. During the first phase of lockdown in Russia, 492 participants were engaged in the survey, which we regard as an insufficient and relatively small sample size. The latter is an essential limitation of our study resulting in several drawbacks. For instance, the latent three-items construct “Activity” representing the joint weights of manifested variables of actual spatial activity patterns has not shown sufficiently internal consistency according to the relatively low Cronbach’s Alpha. This lowering Cronbach’s Alpha value we attribute mostly to the small sample size. However, we claim that the construct “Activity” still is a reliable latent variable since, in the CFA procedure, we have based it on the solid hypothesis that a mobility manifested through the objective behavioral acts of spatial activity included in the current survey. We realize that the “Activity” construct’s essential limitation lies in the sphere of the subjectivity of self-reported spatial activity data. In future studies, the construct “Activity” reliability has to be enhanced by expanding the sample size, introducing repeated measuring into the survey, and/or by implementing the big data and the self-phone individual geopositioning data into the future research design.

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