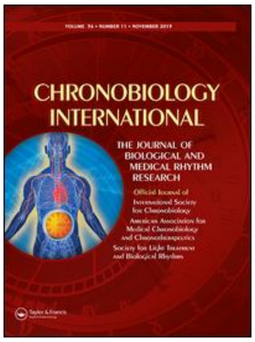

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ORIGINAL ARTICLE

When early and late risers were left to their own devices: six distinct chronotypes under "lockdown" remained dissimilar on their sleep and health problems

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ABSTRACT

Under national "lockdown," the habitual late risers need not wake up early, and, similarly to the early risers, they don't lose much sleep on weekdays. We tested whether, despite a decrease in weekday sleep loss, the difference between distinct chronotypes in health and sleep problems persisted during "lockdown." Two online surveys were conducted from 10th to 20th of May, 2020 and 2021, one of them after 6 non-working weeks and another after 14 working weeks (during and after "lockdown," respectively). Participants were students of the same grade at the same university department (572 and 773, respectively). The self-assessments included the Single-Item Chronotyping (SIC) designed for self-choosing chronotype among several their short descriptions and several questions about general health, mood state, outdoors and physical activity, and sleep concerns. The results suggested that the responses to each of the questions were not randomly distributed over 6 distinct chronotypes. Such a nonrandomness was identified within each of three pairs of these chronotypes, evening vs. morning types (with a rising throughout the day vs. a falling level of alertness, respectively), afternoon vs. napping types (with a peak vs. a dip of alertness in the afternoon, respectively), and vigilant vs. lethargic types (with the levels of alertness being permanently high vs. low, respectively). Morning, afternoon, and vigilant types reported healthier sleep/mood/behavior/habits than three other types. The most and the least healthy sleep/mood/behavior/habits were reported by morning and evening types, respectively. These relationships with health and sleep problems and the frequencies of 6 chronotypes remained unchanged after "lockdown." Such results, in particular, suggested that the association of evening types with poorer health and sleep might not be attributed to a big amount of weekday sleep loss. The accounting for this association might help in designing interventions purposed on reduction of sleep and health problems.

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Introduction

Chronotype refers to the propensity for an individual to sleep or to become more or less active (physically and/or mentally) at a particular time during a 24-hour period. When individuals are typed in accord with their propensity to sleep at a particular time during a 24-hour period, a rather simple, unidimensional classifications might be applied for distinguishing between just two distinct chronotypes, morning (M- or early) type and evening (E- or late) type. E-type is characterized by later bedtimes and wakeups on weekends. As suggested by many reports, a level of depressive symptoms is higher in those of E-types who practice larger shifts of bedtimes and wakeups on weekdays compared weekend bedtimes and wakeups (e.g., De Souza and Hidalgo 2014; Islam et al. 2020; Levandovski et al. 2011; Yasutaka et al. 2020). Such trait as lateness in the morning behaviors (morning component of morningness-eveningness) was also shown to be associated with depression (Booker et al. 1991; Jankowski 2016; Putilov 2018). Moreover, E-type was found to suffer from poorer sleep quality (e.g., Giannotti et al. 2002; Taillard et al. 1999), often in combination with depressed mood (Caruso et al. 2020; Godin et al. 2017). In overall, eveningness was linked to various kinds of unhealthy behaviors and habits (see Adan et al. 2012; Levandovski et al. 2013; Fabio et al. 2016, for review).

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The mechanisms underlying the relationship between eveningness and unhealthy sleep/mood/behavior/habits remain unknown. Several hypotheses were proposed (reviewed by Bullock 2019). One of them suggested that chronic misalignment between internal physiological timing and externally imposed timing of work and social activities might cause the development of unhealthy behaviors and habits in people with late weekend sleep times (Roenneberg and Merrow 2016). However, long before the invention of a five-day workweek, Emil Kraepelin (1856–1926) pointed at a link between eveningness and health problems (Becker et al. 2016).

A more complex and multidimensional classification of chronotypes might be proposed for the propensity of individuals to become more or less active at a particular time during a 24-hour period. Previously, we provided evidence for plausibility of such multi-dimensional approach on the example of daily variation in alertness-sleepiness levels (Putilov et al. 2015, 2019, 2021). It remains, however, unexplored whether the changes in temporal environment (e.g., in the timing of light exposure, work, and social interactions) can influence the proportions of these chronotypes and the pattern of their association with health and sleep problems.

Due to the COVID-19 pandemic, about half of the world's population was under some form of "lockdown" by April 2020. Since people were asked or ordered by their governments to stay at home during this "lockdown," university students were left to their own devices. They need not wake up early in the morning to attend classes, and, consequently, the later rising majority of the university students was not forced to lose a much larger fraction of sleep than the early rising students' minority. It remains to be elucidated whether, due to the reduction of sleep loss on weekdays, the chronotypes became more similar one to another on their complaints about sleep and health. Consequently, we tested whether the differences between them in self-reported sleep and health problems might persist under national "lockdown."

Materials and methods

The university students were surveyed twice, in year 2020 and in year 2021, between May 10th and 20th. The first survey started at the end of 6 all-Russian non-working weeks (between March 25th and May 12th, 2020) when the number of daily confirmed cases of COVID-19 in Russia had already climbed up to its first peak. Under national "lockdown," university students were asked to remain at their homes till the end of the semester. In the beginning of May, each student started to communicate with his/her lecturers via Internet. The lecturers invited them for voluntary participation in this first survey. The survey included several questions about age, gender, health, outdoors and physical activities, sleep problems, and chronotype. The responses were collected from the student's smartphones at the web-page designed for this survey.

The participants of the first survey were 208 male and 364 female university students. Age in the range between 18 and 24 years was reported by 536 of them. Only 26 and 10 students reported ages younger than 18 years and older than 24 years, respectively. The vast majority of survey participants lived in Moscow or other Russian cities. The exception were 72 students living in rural areas and 15 students living abroad.

The second online survey was conducted one year later (2021) after 14 working weeks during which students, as usual, had to attend their classes. Since the participants were recruited from the same grades and from the same department of the Medical Institute of the Peoples' Friendship University of Russia (Moscow), they were expected to have approximately of the same age as the students of the first survey conducted 1 year earlier. Indeed, of 202 male and 571 female university students, 747 reported aged in the range between 18 and 24 years. Only 16 and 10 students were younger than 18 and older than 24, respectively. At the time of the second survey, all its participants lived in Moscow.

The survey participants responded to the 1st (in the first survey) or the last (in the second survey) item designed for one-click chronotyping. The original (English) version of the SIC (Single-Item-Chronotyping) was previously proposed by Olivier Mairesse and Arcady Putilov (Putilov et al. 2021) for distinguishing between 7 chronotypes. Their English names (Table 1) were abbreviated as "LIVEMAN" ("Lethargic," "Inconclusive," "Vigilant," "Evening," "Morning," "Afternoon," and "Napping"). Seven response options to the only SIC's question ("Self-assess your chronotype by choosing one of six patterns of daily change in alertness level") included the names of these types in Russian translation and the following short descriptions:

- Lethargic ("Moderately energetic" in Russian) "type: low level in the morning, low in the afternoon, low in the evening";
- Vigilant ("Highly energetic" in Russian) "type: high level in the morning, high in the afternoon, high in the evening";
- "Evening type: low level in the morning, middle in the afternoon, high in the evening";
- "Morning type: high level in the morning, middle in the afternoon, low in the evening";

Table 1. Associations of "lockdown" and weekend bedtime with health, sleep, LIVEMAN, etc.

Association with Sample or Subsample	"Lockdown" During, $N = 572$				Weekend bedtime after "Lockdown" Late, ≥ 2:00, $N = 305$				Early, < 1:00, $N = 275$			
Response option	n	χ^2_1	p		n	χ^2_1	p		n	χ^2_1	p	
Health: "Not good"	150	46.0	<0.001	↑↑	147	3.2	0.074	↑	106	5.6	0.018	↓
Mood state: "Depressed"	84	0.5	0.446		56	11.1	0.001	↑↑	29	2.9	0.091	↓
Mood state: "Euphoric"	35	1.1	0.282		23	0.0	0.938		23	0.3	0.569	
Physical activity: "Low"	156	6.0	0.014	↑	107	0.6	0.454		69	13.6	<0.001	↓↓
Physical activity: "High"	84	0.0	0.975		40	1.1	0.301		49	3.2	0.074	↑
Outdoors: "< 1 h"	204	99.8	<0.001	↑↑	35	0.7	0.417		34	0.0	0.845	
Outdoors: "≥ 3 h"	206	56.9	<0.001	↓↓	188	4.9	0.028	↑	155	0.0	0.858	
Any of 4 sleep concerns	334	0.8	0.359		189	7.6	0.006	↑	143	2.6	0.106	
Difficulties falling asleep	170	14.9	<0.001	↑↑	77	6.7	0.009	↑	48	2.5	0.111	
Mid-sleep awakenings	17	1.3	0.258		11	0.4	0.548		14	1.0	0.324	
Early awakenings	48	0.0	0.941		22	0.8	0.385		27	2.3	0.249	
Daytime sleepiness	99	6.3	0.012	↓	79	2.6	0.109		54	2.6	0.109	
Partner's concern	146	11.2	0.001	↑↑	129	15.4	<0.001	↑↑	84	2.3	0.129	
L(ethargic)	16	0.3	0.555		8	0.9	0.357		13	2.4	0.118	
I(nconclusive)	16	9.5	0.002	↓↓	18	0.3	0.605		21	1.0	0.327	
V(igilant)	59	1.4	0.232		29	0.8	0.374		22	0.1	0.761	
E(vening)	210	1.3	0.262		135	24.8	<0.001	↑↑	57	32.4	<0.001	↓↓
M(orning)	105	0.1	0.765		27	27.2	<0.001	↓↓	72	20.9	<0.001	↑↑
A(fternoon)	125	0.4	0.530		57	1.0	0.330		62	1.2	0.281	
N(apping)	41	2.9	0.087	↓	31	0.1	0.802		28	0.1	0.808	

"Lockdown": Comparison of samples collected During and after "lockdown"; Late or Early: A subsample was compared with the rest of the sample; n, χ^2_1, and p: Actual count, chi-square, and level of significance (4-cell 2-sided Pearson Chi-Square test); ↓ or ↑: Actual count was either lower or higher than expected count; ↓↓ and ↑↑: The difference remained significant after accounting for the number of comparisons ($p_{corrected} = 0.05/20 = 0.0025$). Two Response options to the question: "What is your health state?," "So-so" and "Bad," were combined in "Not good"; "Depressed" and "Euphoric" are Responses to the question: "What is your mood state?"; two Response options to the question "What is your physical activity level?," "Extremely inactive" and "Sedentary," were combined in "Physical activity: Low"; Outdoors: Hours spent outdoors during a day. Sleep concerns were determined from the answers to the question "What is your main concern about your sleep?"; Partner's concern: Choosing either "No" or "Yes" in Response to the question "Have you a partner complaining about your sleep or your sleep-related daytime performance?"; LIVEMAN: Types chosen among the short descriptions of 6 patterns of daily change in alertness level, with the 7th Response option for I-type "None of the above."

- Afternoon ("Daytime" in Russian) "type: low level in the morning, high in the afternoon, middle in the evening";
- Napping ("Daytime sleepy" in Russian) "type: high level in the morning, low in the afternoon, middle in the evening";
- Inconclusive type ("None of the above" in Russian).

The responses ##1-7 to the SIC were used to subdivide the whole sample into 7 subsamples. Six of these chronotypes can be grouped in three opposing pairs characterized by different level (high vs. low), phase (early vs. late), and wave-form (peak vs. dip in the afternoon) of the diurnal alertness-sleepiness rhythm, V–vs. L-, M- vs. E-, A- vs. N-type, respectively (Table 3 vs. Table 2, respectively).

Six other questions (Table 1) asked about general health and mood state, outdoors and physical activity, and sleep concerns. In the second survey, responses about weekday and weekend bedtimes and wakeups were collected to classify the participants in accord with state-like individual difference between them in weekend sleep timing (Table 1).

The $SPSS_{23.0}$ statistical software package (IBM, Armonk, NY, USA) was used for statistical analyses. The responses (Table 1–3) were distributed over subsamples of chronotypes and the Pearson Chi-Square test (χ^2) was applied to examine whether an actual count of a response to a question significantly deviated from an expected count, i.e., when the random distribution of these responses over chronotypes was suggested. Level of significance of each statistical result was corrected to account for the number of compared responses (Table 1–3).

Results

As it was expected, students with later weekend sleep timing (late types) differed from students with earlier sleep timing (early types) in reporting more health and sleep complaints. Table 1 (middle and right) illustrates this relationship on the example of students with different weekend bedtimes. Almost identical relationships were found for a pair of opposing each other evening and morning (E- and M-) types (Tables 2 and 3, respectively). A better health and sleep were also found for vigilant and afternoon (V- and A-) types (Table 3), while health and sleep problems were more often reported by lethargic and napping (L- and N-) types (Table 2). All such associations were also among expected, but the contrast seemed to be less drastic for these two opposing pairs of chronotypes as compared to the contrast observed between morning and evening types (Table 1–3). As indicated by the results reported in lover and upper parts of Tables 2

Table 2. Associations of L-, E-, and N-types with gender, health, sleep, etc.

Response option	*n*	χ^2_1	*p*		*n*	χ^2_1	*p*		*n*	χ^2_1	*p*	
During, *N* = 572		L(ethargic), *N* = 16				E(vening), *N* = 210				N(apping), *N* = 41		
Gender: "Female"	10	0.0	0.924		142	2.3	0.132		28	0.4	0.520	
Health: "Not good"	7	2.6	0.106		70	8.7	0.003	↑↑	11	0.0	0.927	
Mood state: "Depressed"	2	0.1	0.802		37	2.3	0.131		11	5.2	0.023	↑
Mood state: "Euphoric"	1	0.0	0.982		14	0.2	0.677		3	0.1	0.740	
Physical activity: "Low"	4	0.0	0.836		58	0.0	0.887		17	4.9	0.034	↑
Physical activity: "High"	2	0.1	0.802		20	7.1	0.008	↓	4	0.9	0.355	
Outdoors: "< 1 h"	6	0.0	0.876		81	1.2	0.269		11	1.5	0.220	
Outdoors: "≥ 3 h"	4	0.9	0.352		70	1.0	0.309		17	0.6	0.451	
Any of 4 sleep concerns	10	0.1	0.735		144	14.2	<0.001	↑↑	29	2.8	0.096	↑
Difficulties falling asleep	5	0.0	0.892		82	13.8	<0.001	↑↑	8	2.2	0.138	
Mid-sleep awakenings	0	0.5	0.478		7	0.2	0.698		1	0.0	0.835	
Early awakenings	2	0.4	0.548		5	15.6	<0.001	↓↓	3	0.1	0.797	
Daytime sleepiness	3	0.0	0.877		50	9.2	0.002	↑↑	17	18.0	<0.001	↑↑
Partner's concern	4	0.0	0.861		68	8.2	0.004	↑	15	2.8	0.092	↑
After, *N* = 773 L(ethargic), *N* = 26			E(vening), *N* = 261					N(apping), *N* = 76				
Gender: "Female"	19	0.0	0.926		198	0.8	0.368		69	12.5	<0.001	↑↑
Health: "Not good"	17	4.9	0.027	↑	136	9.9	0.002	↑↑	38	1.1	0.287	
Mood state: "Depressed"	11	19.6	<0.001	↑↑	33	0.2	0.691		15	3.0	0.083	↑
Mood state: "Euphoric"	1	0.5	0.459		22	0.4	0.552		2	3.0	0.084	↓
Physical activity: "Low"	13	3.3	0.070	↑	98	2.9	0.089	↑	31	2.0	0.157	
Physical activity: "High"	0	4.7	0.031	↓	28	5.1	0.024	↓	12	0.1	0.787	
Outdoors: "< 1 h"	2	0.6	0.437		37	0.8	0.371		12	0.7	0.391	
Outdoors: "≥ 3 h"	16	0.2	0.619		151	0.2	0.670		47	0.9	0.349	
Any of 4 sleep concerns	20	4.8	0.028	↑	168	11.5	<0.001	↑↑	53	6.6	0.010	↑
Difficulties falling asleep	1	4.6	0.032	↓	59	1.0	0.317		13	0.6	0.431	
Mid-sleep awakenings	2	0.9	0.355		11	0.0	0.941		0	3.6	0.056	↓
Early awakenings	6	7.8	0.005	↑	14	4.4	0.036	↓	8	0.6	0.454	
Daytime sleepiness	11	5.7	0.017	↑	84	19.2	<0.001	↑↑	32	17.6	<0.001	↑↑
Partner's concern	13	3.1	0.080	↑	110	11.6	0.001	↑↑	32	2.5	0.117	

During and After: During and After "Lockdown"; L(ethargic) or E(vening) or N(apping): A subsample was compared with the rest of the sample; *n*, χ^2_1, and *p*: Actual count, chi-square, and level of significance (4-cell 2-sided Pearson Chi-Square test); ↓ or ↑: Actual count was either lower or higher than expected count; ↓↓ and ↑↑: The difference remained significant after accounting for the number of comparisons ($p_{corrected}$ = 0.05/16 = 0.0035).

Table 3. Associations of V-, M-, and A-types with gender, health, sleep, etc.

Response option	*n*	χ^2_1	*p*		*n*	χ^2_1	*p*		*n*	χ^2_1	*p*	
During, *N* = 572		V(igilant), *N* = 59				M(orning), *N* = 105				A(fternoon), *N* = 125		
Gender: "Female"	19	28.1	<0.001	↓↓	70	0.5	0.475		87	2.5	0.117	
Health: "Not good"	9	4.1	0.043	↓	17	6.7	0.010	↓	32	0.0	0.858	
Mood state: "Depressed"	5	2.0	0.155		7	6.6	0.010	↓	17	0.2	0.698	
Mood state: "Euphoric"	13	29.0	<0.001	↑↑	0	8.4	0.004	↓	4	2.4	0.124	
Physical activity: "Low"	4	13.9	<0.001	↓↓	28	0.0	0.877		41	2.5	0.117	
Physical activity: "High"	25	40.3	<0.001	↑↑	18	0.6	0.431		11	4.4	0.035	↓
Outdoors: "< 1 h"	16	2.1	0.148		35	0.3	0.581		45	0.0	0.929	
Outdoors: "≥ 3 h"	32	9.5	0.002	↑↑	37	0.0	0.855		43	0.2	0.671	
Any of 4 sleep concerns	28	3.2	0.072	↓	46	11.3	0.001	↓↓	68	1.0	0.306	
Difficulties falling asleep	12	2.8	0.096	↓	18	9.7	0.002	↓↓	38	0.0	0.851	
Mid-sleep awakenings	2	0.0	0.842		5	1.4	0.232		2	1.0	0.307	
Early awakenings	14	20.1	<0.001	↑↑	15	5.8	0.016	↑	9	0.3	0.587	
Daytime sleepiness	0	13.8	<0.001	↓↓	8	8.4	0.004	↓	19	0.5	0.481	
Partner's concern	12	0.9	0.335		23	0.9	0.346		21	6.4	0.011	↓
After, *N* = 773 V(igilant), *N* = 65			M(orning), *N* = 137					A(fternoon), *N* = 158				
Gender: "Female"	36	12.6	<0.001	↓↓	93	3.1	0.079	↓	124	2.2	0.139	
Health: "Not good"	20	5.2	0.022	↓	45	8.8	0.003	↓↓	68	0.1	0.732	
Mood state: "Depressed"	0	10.9	0.001	↓↓	9	6.6	0.010	↓	27	2.4	0.119	
Mood state: "Euphoric"	9	3.9	0.049	↑	13	0.8	0.367		10	0.5	0.489	
Physical activity: "Low"	14	4.6	0.033	↓	35	4.7	0.030	↓	52	0.0	0.859	
Physical activity: "High"	23	24.0	<0.001	↑↑	25	1.6	0.203		15	4.4	0.037	↓
Outdoors: "< 1 h"	2	5.9	0.015	↓	14	0.9	0.340		23	0.6	0.426	
Outdoors: "≥ 3 h"	49	10.0	0.002	↑↑	69	2.8	0.094	↓	88	0.1	0.755	
Any of 4 sleep concerns	25	8.7	0.003	↓↓	67	3.3	0.070	↓	79	2.8	0.095	↓
Difficulties falling asleep	11	0.6	0.447		35	2.5	0.112		30	0.3	0.581	
Mid-sleep awakenings	5	2.3	0.133		7	0.4	0.530		6	0.1	0.809	
Early awakenings	8	1.5	0.218		12	0.1	0.822		14	0.1	0.766	
Daytime sleepiness	1	18.3	<0.001	↓↓	13	17.0	<0.001	↓↓	29	2.3	0.128	
Partner's concern	14	4.9	0.026	↓	39	2.2	0.130		44	3.4	0.066	↓

During and After: During and After "Lockdown"; V(igilant) or M(orning) or A(fternoon): A subsample was compared with the rest of the sample; *n*, χ^2_1, and *p*: Actual count, chi-square, and level of significance (4-cell 2-sided Pearson Chi-Square test); ↓ or ↑: Actual count was either lower or higher than expected count; ↓↓ and ↑↑: The difference remained significant after accounting for the number of comparisons ($p_{corrected}$ = 0.05/16 = 0.0035).

and 3, the differences between distinct chronotypes in their sleep and health concerns during "lockdown" were almost fully identical to the differences between them after "lockdown." Even more, the prevalence of E- and M-types did not differ significantly during and after "lockdown" (Table 1, left).

Discussion

In the present study, we tested whether the differences between distinct chronotypes in health and sleep problems persisted during "lockdown" despite the tendency of the habitual late risers to became similar to the early risers on weekday sleep duration. We found that the prevalence of E- and M-types did not differ significantly during and after "lockdown," and that, during both surveys, the former and the latter types reported the unhealthiest and the healthiest sleep/mood/behavior/habits, respectively. Thus, E-types that are the most frequently reported student's chronotypes may have most common and most detrimental outcomes for health and sleep even when they have an opportunity to escape from profound sleep losses on weekdays. Results on other chronotypes also allowed the conclusion that, when it comes to sleep and health concerns, the differences between them persisted under "lockdown."

The differences in sleep and health concerns between early (or M-) and late (or E-) types were in line with the previously reported findings suggesting a link of the latter type to depressed mood and sleep problems (Booker et al. 1991; Jankowski 2016; Giannotti et al. 2002; Taillard et al., 1999; Godin et al. 2017; Caruso et al. 2020). Drennan et al. (1991) pioneered the studies suggesting that eveningness is a potential risk factor for depression. This suggestion was supported by several further publications (e.g., Alvaro et al. 2014; Randler 2011). Morningness and earlier bedtimes were proposed to be, in contrast, the factors protecting against depression (e.g., Gangwisch et al. 2010; Gelbmann et al. 2012). Such cross-sectional studies, however, could not prove cause and effect relationships. Here, we found a link of E-type with depressed mood in the specific condition: when this type does not lose a much larger fraction of sleep on weekdays than M-type. Therefore, our results allow the conclusion that the association of E-type with poorer sleep and health might not be attributed to the late sleep timing on weekends causing the reduction of sleep duration on weekdays.

This is the first report indicating that there are also significant differences in sleep and health problems between 4 types from two other pairs of opposing chronotypes. However, further studies on independent samples are required for the confirmation of these differences.

The advantage of the present survey was its simplicity, lightness, high speed, and swiftness, but this can be, on the other hand, listed among its limitations. For instance, evaluation of reliability of one-item self-assessments is not possible, and, therefore, future studies are required to support the present results and to validate these instruments with multi-item scales of multidimensional questionnaires. Finally, the limitation of our survey is the absence of data allowing the comparison of chronotypes on objective measures of sleep quality and timing, daily changes in levels of alertness-sleepiness, levels of physical and mental activity, etc.

Conclusions

The difference in self-reported sleep and health problems between six chronotypes persisted under "lockdown." Unhealthy sleep/mood/behavior/habits were found to be more common for L-, E-, and A-types and less common for V-, M-, and N-types. E-types, that were more prevalent compared to the three healthier chronotypes both during and after "lockdown," seem to have the most detrimental outcomes for their health and sleep even during "lockdown."

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Ethical approval

The survey was conducted in accordance with the ethical standards of the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The Ethics Committee of the Medical Institute of the Peoples' Friendship University of Russia approved the survey.

Authors contributions

AAP designed the survey, AAP and DSS designed the web page, AAP, DSS, ZBB, EBY, YPS, VIT, RPL, ROB, EVB, ANP, and VBD equally contributed to data collection and analysis, and AAP wrote the paper.

Data availability

The dataset is available on reasonable request to the corresponding author.

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