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Economic factors influencing the health behavior changes during COVID-19 pandemic: multiple correspondence analysis results

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Abstract

This research aimed to investigate how health behaviors changed during the COVID-19 pandemic and to identify the economic factors influencing these changes. There were considered income situation and labor market situation as the potential economic factors. Additionally, in the analysis, there were included other characteristics: age, gender, and education level. Health condition was considered through the prism of certain unhealthy characteristics: alcohol consumption, smoking cigarettes, lack of physical activity, and unfavorable eating habits. The study was carried out on the stratified sample of adult inhabitants of Poland (N=1067) in November 2020. To achieve the aim multiple correspondence analysis was used. The results show that the pandemic has changed health behaviors. The negative changes mainly concerned physical activity and eating habits, and only one-sixth reported an increase in alcohol use and cigarette smoking. An increase in negative health behavior was mostly associated with the following characteristics: male, lower age (between 30 and 59), employed persons, tertiary education, and higher income (the fourth and the fifth income quintile group). The exception was a physical activity, where all changes (both negative and positive) were associated with females, people with basic vocational and secondary education, the second and third quintile group, pensioners and retirees, 60 and above age.

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1. Introduction

Economics and health are closely related. This relationship is especially visible during the COVID-19 pandemic. On the one hand, the economic impact of COVID-19 is enormous and therefore the numerous studies were already devoted to this problem [1–4]. The authors emphasize, *inter alia*, that to reach the Sustainable Development Goals (SDG) the assumptions have been made: globalization and sustained economic growth. The pandemic has shaken the whole SDG project. Naidoo and Fisher [5] reported that two-thirds of the 169 targets will not be accomplished by 2030. On the other hand, richer countries can fight the pandemic more effectively because they have more resources to protect the health of their citizens. For example, on April 19, 2021, the share of the population that received at least one vaccine dose in Israel was almost 62%, in the United Kingdom about 48%, in Brazil more than 11%, in India almost 8%, but in Nigeria only 0.5% [6]. The relationship between economics and health is visible not only at the country level but also at the individual level. Limitation of economic activities in the form of lockdowns causes job loss, bankruptcy, and many psychological consequences for people. Therefore, modifications to lifestyle behaviors are largely inevitable. These are likely to include changes in sleep, alcohol consumption, physical activity as well as dietary habits, and even the incidence of domestic violence cases [7]. The COVID-19 pandemic and “stay-at-home” action may cause positive health behaviors (sleep, physical activity) and negative health behaviors (alcohol consumption, drug use, and tobacco use). Negative health behaviors may cause a lot of consequences, such as liver diseases, cancers, asthma, cardiovascular diseases [8]. The consequences are also visible for a whole society because poor health of citizens of a country is related to higher costs of health care.

This research aimed to investigate how health behaviors changed during the COVID-19 pandemic and to identify the economic factors influencing these changes. There were considered four health behaviors: alcohol consumption, smoking cigarettes, lack of physical activity, unfavorable eating habits.

2. Methods

The study was based on a stratified sample (N=1067), selected from the general population of adults in Poland. In November 2020, 1067 adult inhabitants were interviewed (CAWI technique, Computer-Assisted Web Interviewing). The questions about health behavior were following: “I drink more alcohol”, “I smoke more cigarettes”, “I am less physically active”, “I eat more”. The respondents may answer “yes”, “no”, and “not applicable”. The point of reference was the pre-pandemic situation (before March 2020).

The multiple correspondence analysis was used to identify the factors influencing health behavior changes. There were considered economic characteristics: personal income and labor status market. Additionally, in the analysis, there were included other characteristics of the respondents: age, gender, and education level.

Correspondence analysis is a variant of principal component analysis used to analyze categorical data. The method provides a graphical representation of cross-tabulation. Simple correspondence analysis (CA) applies to the cross-tabulation of two categorical variables, while multiple correspondence analysis (MCA) applies to more than two categorical variables [9–12]. Correspondence analysis is the method widely used in different types of studies. In the previous studies, CA was used to identify the position of overseas golf tourism destinations by Korean golf tourists [13], to the identification of the influence of features of unemployed persons on the unemployment duration [14], to create the perception map for data describing the extent of poverty and some socio-economic characteristics [15]. MCA was used to identify socio-economic factors conditioning voluntary life insurance [16], to diagnose whether (and to what extent) banks affect the decisions and business models of enterprises [17], to know the preferences and motivations of tourists for the choice of destinations to visit [18], to identify candidate genes associated with flowering and sex determination in yams [19].

An algorithm for performing a CA is following [20–22]:

1. The determination of the correspondence matrix based on the frequency table.
2. The determination of row and column mass.
3. The determination of row and column profiles.
4. The calculation of using chi-square metric. Important terms related to chi-square metric:

- the weighted sum of the squared chi-square distance between each row profile and the average row profile is the total variance, or “inertia”.
 - in CA eigenvalues and inertia are synonymous in that, each axis has an eigenvalue whose sum equals the inertia of the cloud (mass of points).
5. Graphical presentation of the results of CA on the multidimensional map also called a biplot (typically consists of two dimensions, less often three dimensions). The plot presents all categories of the studied variables.

The graphical presentation of the CA results should not be considered as the final result, because the interpretation is subjective. The results may be verified using one of the hierarchical methods, e.g. Ward’s method [20]. For this purpose, the coordinates of points presented on the biplot are used. Hierarchical methods allow to create a dendrogram and to identify clusters. There is no generally valid cut-off value up to which the clusters should be selected. Clustering should be discontinued in every case if there are large gaps in heterogeneity [20,23].

The MCA is a correspondence analysis applying to a Burt matrix (the most often) or an indicator matrix [24]. The Burt matrix is a symmetric matrix of all two-way cross-tabulations between the categorical variables and the indicator matrix is a matrix with cases as rows and categories of variables as columns.

All statistical calculations and plots were performed in SPSS [25].

3. Results

Table 1 shows the characteristics of the study sample – a set of the potential factors influencing health behavior changes.

Table 1. Set of the potential factors influencing health behavior changes.

Variables	Description of the categories	% or mean (SD)
Age	18-29	20.1
	30-44	28.4
	45-59	24.4
	60 and above	27.1
Education level	not higher than lower secondary	2.3
	basic vocational	10.3
	secondary	47.2
	tertiary	40.1
Gender	male	47.6
	female	52.4
Labor market status	employed person	60.9
	unemployed person	5.7
	retiree	21.0
	pensioner	3,7
	student	4.5
	pupil	1.9
Income quintile group (PLN)	other economically inactive person	2.2
	1	560.72 (440.63)
	2	1761.36 (243.59)
	3	2414.13 (177.49)
	4	3147.65 (232.64)
	5	4721.21 (1144.03)

The majority of the sample (52.4%) was female. The largest share had people from age category 30-44 (28.4%), with secondary education (47.2%), and being employed (60.9%). The sample was diversified in terms of income: the mean income in the first quantile group was eight times lower than in the fifth quantile group (PLN 560.72 and PLN 4721.21, respectively).

During the COVID-19 pandemic, the negative health behaviors mainly concerned physical activity (56.5%) and eating habits (34.0%), and only one-sixth reported an increase in alcohol use and cigarette smoking (17.0% and 16.5%, respectively).

Detailed analysis of association between negative health behaviors and socio-economic characteristics is illustrated in Fig. 1.

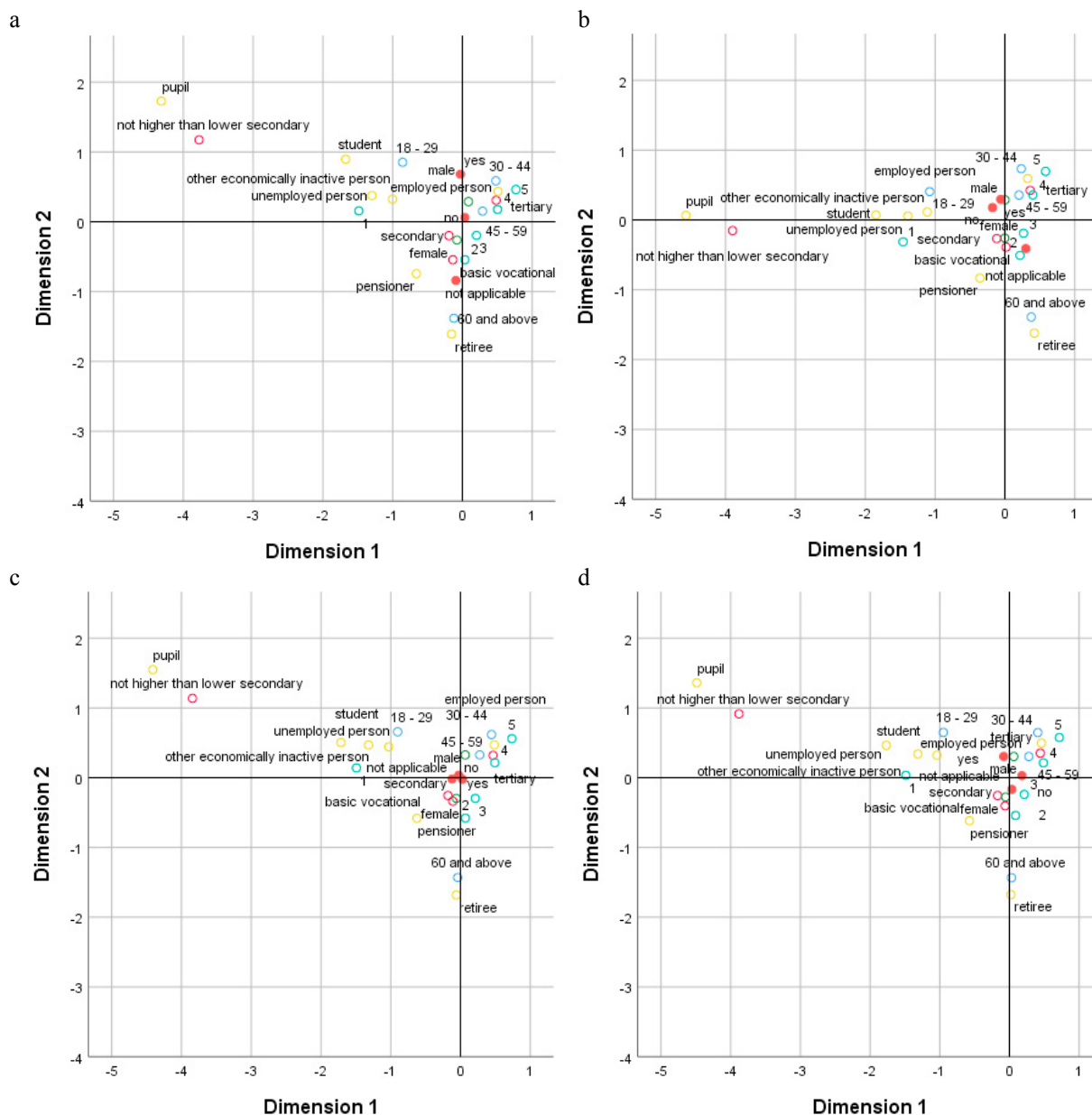


Fig. 1. The results of MCA: socio-economic characteristics and (a) drinking more alcohol; (b) smoking more cigarettes; (c) being less physically active; (d) eating more.

Studying the association between drinking more alcohol and socio-economic characteristics (Fig. 1a), in MCA, the first and second dimensions presented, respectively, eigenvalues of 2.082 and 2.081 and inertia of 0.347 (34.7% of variance explained) in both cases. In total, this was an eigenvalue of 4.162 and inertia of 0.694 (69.4% of variance explained). The variables with the most discriminating power in the first dimension were labor market status and quantile group. The second dimension was mostly defined by labor market status and age.

Applying MCA to study the association between smoking more cigarettes and potential factors (Fig. 1b), the first and the second dimensions explained 34.9% and 33.7% of the total variance, respectively. The eigenvalues were 2.096 (the first dimension) and 2.021 (the second dimension). In total, this was an eigenvalue of 4.118 and 68.6% of variance explained. As in the previous analysis, the first dimension was mostly defined by labor market status and quantile group, and the second dimension by labor market status and age.

In the case of being less physically active (Fig. 1c) dimension 1 and dimension 2 explained 34.7% and 32.8% of the total variance, respectively. In total, two identified dimensions explained 67.5% of the inertia. The eigenvalues were 2.082 (the first dimension), 1.968 (the second dimension), 4.050 (in total). Again, the most discriminating power had labor market status and quintile group (dimension 1) and labor market status and age (dimension 2).

By applying the MCA to the study of the association between eating more and some potential socio-economic characteristics (Fig. 1d), there were identified two dimensions, which explained 67.9% of the inertia (eigenvalue equals to 4.074). The percentages of total variance explained by each dimension are the following: the first dimension explained 34.7% of the total variance and the second dimension explained 33.2% of the total variance. The eigenvalues were 2.083 and 1.992, respectively. As in the previous analyzes, the most discriminating power had the same variables.

The results of MCA were verified using Ward's method and dividing the dendrogram into clusters (Fig. 2). As a result of the combination of these methods, it can be concluded that:

- “Not applicable” answer to the statement “I drink more alcohol” was associated with female, secondary level of education, retiree, pensioner, 60 and above, second and third quintile group. The statements “yes” and “no” were associated with men, lower age (between 30 and 59), employed persons, tertiary education, and with higher income (the fourth and the fifth income quintile group).
- The answer “not applicable” to the statement “I smoke more cigarettes” was associated with secondary and basic level of education, group of women, age 60 and above, retiree and pensioner, and two income quintile groups (the second and the third). “Yes” and “no” answers were associated with men, lower age (between 30 and 59), employed persons, tertiary education, and with higher income (the fourth and the fifth income quintile group).
- All answers to the statement “I am less physically active” were associated with the following characteristics: female, basic vocational and secondary education, the second and third income quintile group, pensioners and retirees, 60 and above age. The answers were close to the origin on the plot (Fig. 3), which means the similarity the response profile to the average profile and therefore the results should be interpreted with some caution.
- “No” and “not applicable” answers to the statement “I eat more” were associated with female, basic vocational and secondary education, the second and the third income quintile group, pensioner. Answer “Yes” was associated with men, lower age (between 30 and 59), employed persons, tertiary education, and with higher income (the fourth and the fifth income quintile group).

4. Discussion

The present study indicates that the pandemic has changed health behaviors. The negative changes mainly concerned physical activity and eating habits, and only one-sixth reported an increase in alcohol use and cigarette smoking. An increase in negative health behavior was mostly associated with the following characteristics: male, lower age (between 30 and 59), employed persons, tertiary education, and higher income (4 and 5 quintile group). The exception was a physical activity, where all changes (both negative and positive) were associated with female, people with basic vocational and secondary education, the second and third quintile group, pensioners and retirees, 60 and above age.

Our findings concerning physical activity and eating habits are in line with previous research. For example, in Spain, a lockdown period due to COVID-19 had a negative impact on the physical activity levels, sleep quality, and

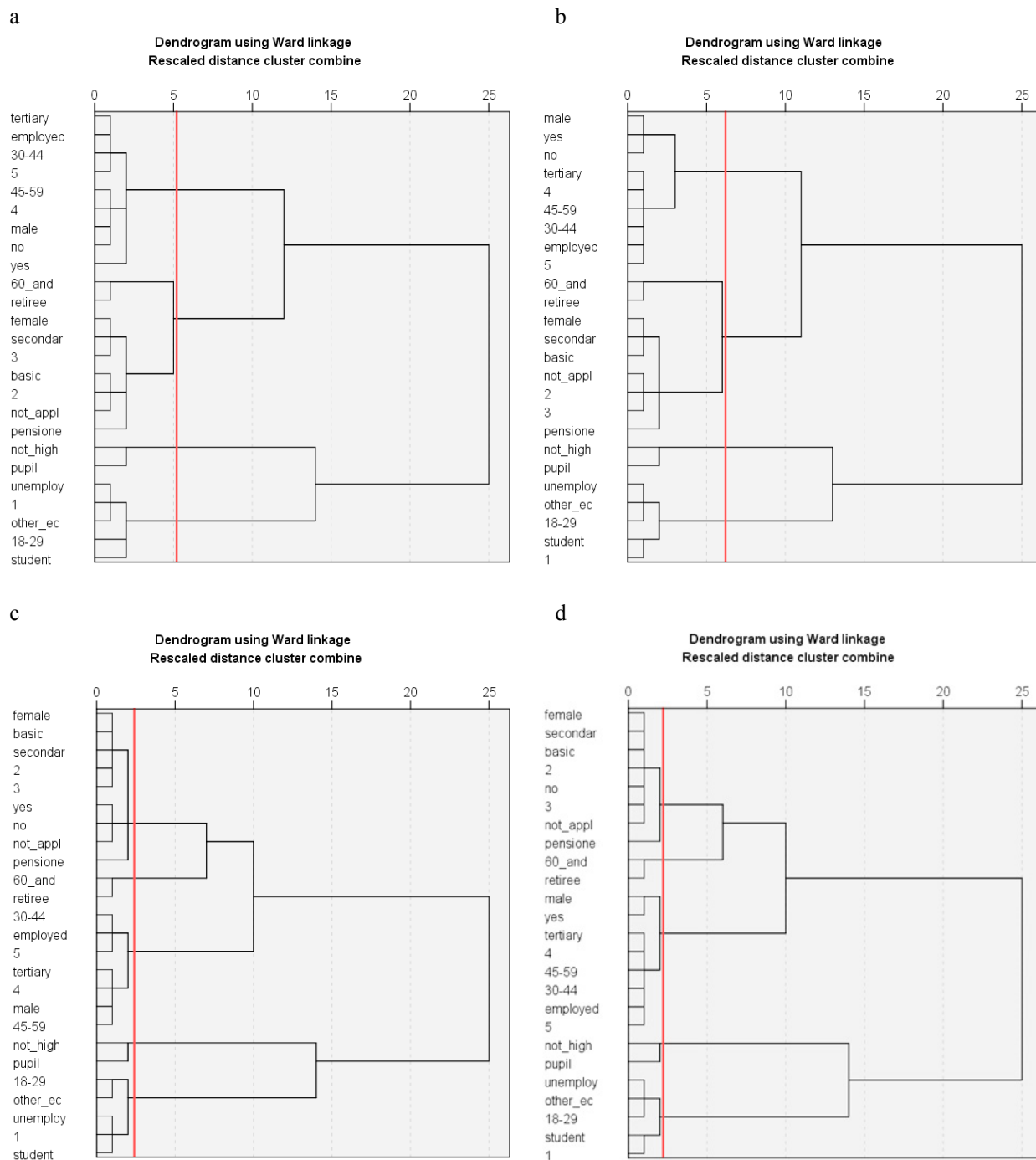


Fig. 2. Hierarchical cluster analysis (Ward method) (a) drinking more alcohol; (b) smoking more cigarettes; (c) being less physically active; (d) eating more.

well-being in a group of physically active adults [26,27]. During the lockdown, a large percentage of French adults reported a decrease in physical activity and an increase in snacking, consumption of sweets, cookies, and cakes [28]. Also in the United Kingdom, a large number of adults reported negative changes in eating and physical activity behavior (e.g. 56% reported snacking more frequently) and experiencing barriers to weight management (e.g. problems with motivation and control around food) compared to before lockdown [29]. During the quarantine, in Lithuania, almost half of the respondents ate more than usual. A decrease in physical activity was reported by almost two-thirds of the studied sample [30]. During the pandemic, in the United States, participants primarily reported a decrease in physical activity. This negative change was related to sex, age, parental status, educational status, job status, BMI, and depression scores [31]. In Brazil, the physical activity level adopted during the period of social distancing was lower than that adopted before the pandemic period [32]. In the city of Quito (Ecuador) people from 18 to 41 years old, with a university education, regardless of their income, decreased their physical activity during quarantine, people with incomes of up to \$ 400 per month changed their eating habits to unhealthy since the emergency began [33].

The reported negative changes in alcohol consumption and smoking cigarettes were also similar to results obtained in other studies. The factors influencing these changes, however, are often different than observed in our study, because researchers often take into account different sets of potential factors. In Belgium, during the lockdown, individuals consumed slightly more alcohol and smoked marginally more cigarettes compared to the period before the lockdown. The odds of consuming more alcohol during the lockdown were associated with younger age, more children at home, nonhealthcare workers, and being technically unemployed related to COVID-19. The odds of smoking more cigarettes during the lockdown were associated with younger age, current living situation, lower education, and working situation related to COVID-19 [34]. In the United States, adults over 21 years reported perceived increases in their current alcohol intake compared to pre-COVID-19 (60% reported increased drinking but 13% reported decreased drinking, compared to pre-COVID-19) [35]. In Indonesia, during the pandemic, almost half of the respondents reported stable alcohol consumption and cigarette consumption. Increased alcohol consumption was negatively correlated with being unmarried. Increased cigarette smoking was positively correlated with being male and unmarried. The other sociodemographic variables (e.g. education, income, occupation) were not statistically significant [36]. During the COVID-19 pandemic in China, a high proportion of people with diabetes perceived the risk of COVID-19 infection and increased their smoking and drinking during the pandemic [37]. Based on the cross-sectional study conducted in 83 countries it can be stated that although drinking behaviors decreased overall during quarantine, more than one-third reported an increase in alcohol use. Those who increased alcohol use during the quarantine were older individuals, essential workers, individuals with children, those with a personal relationship with someone severely ill from COVID-19, and those with higher depression, anxiety, and positive urgency impulsivity [38].

There are limitations to the present research. Questionnaire items examining self-reported changes in unhealthy behaviors compared to before lockdown measure perceived rather than actual change. Another limitation is associated with fact that our study was a single study generalizing the situation before the pandemic and during the pandemic. It must be noted that the COVID-19 pandemic referred to a period with heterogeneous conditions – during the pandemic the government changed many times the level of restrictions. Besides, the behaviors of the respondents may change and the study should be repeated to investigate the trend. Additionally, the changes in behaviors may be related to other factors not included in the presented study (e.g. parental status, the change in respondent's situation on the labor market).

5. Conclusion

During the COVID-19 pandemic in Poland, health behaviors have changed. Particularly worrying is the high percentage of people who have decreased their physical activity. Considering the fact that one-third of respondents reported eating more during the pandemic, it can be expected an increasing prevalence of overweight and obesity. The more obese and overweight people, the more negative consequences for the individuals and for the whole health care system. Therefore, public health efforts should address the potential for long-term health consequences due to behavior change during COVID-19.

Another problem is that the majority of negative changes in health behavior were associated with the high-educated and affluent group of people. This group – because of achieved socio-economic position – is a benchmarking group for low-educated and poorer people. It can be expected that this part of society will copy the lifestyle of the richer and

more educated people. Therefore, another very important issue is to prevent this situation by encouraging people to return to a healthy lifestyle. Promotion of positive health behaviors is needed right here and right now.

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