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**A network analysis of adolescent mental well-being during the coronavirus pandemic:
Evidence for cross-cultural differences in central features**

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Abstract

The COVID-19 pandemic continues to pose unprecedented threat globally. Adolescents and youth may be especially susceptible to the long-term impact of these stressors, thus intervening early is an important priority. However, it is also crucial to understand how young people maintain psychological well-being in the face of adversity, particularly given that many nations are experiencing further waves of the pandemic. The understanding of such resilient outcomes could inform the development of programs to encourage positive mental health. We explored adolescents' resilience to the COVID-19 pandemic stress by examining core aspects of well-being across countries using network analysis. Using the short Warwick–Edinburgh Mental Wellbeing Scale, cross-sectional data was collected online from adolescents from India (N=310; Males=159, Females=151, aged 12-18), Israel (N=306; Males=154, Females=152, aged 12-18) and the United Kingdom (UK; N=1666; Males=598, Females=1068, aged 12-25). Two highly similar network clusters were identified for UK and Israel, with three clusters emerging for India. UK and Israeli networks centred on “dealing with problems well” while Indian centred on “feeling useful”. As central items highlight aspects of well-being that influence or are influenced by other aspects, these findings may inform interventions to safeguard adolescent mental health during future phases of the pandemic.

Keywords: resilience, well-being, young people, network analysis, COVID-19, cross-cultural

A network analysis of adolescent mental well-being during the coronavirus pandemic: Evidence for cross-cultural differences in central features

Many young people around the world have been emotionally affected by the COVID-19 pandemic (Götzinger et al., 2020) and this emotional impact and mental distress may translate into a higher risk of developing mental health problems (World Health Organization, 2020). High (Zhou et al., 2020) and potentially increasing (Qu et al., 2020) rates of common mental disorders such as anxiety and depression have been reported in adolescents during the pandemic, which may result in lasting repercussions on the physical health, educational outcomes, and future employment of youngsters (Choi, 2018; Hewlett & Moran, 2014). Young people have faced challenges such as restrictions on socialisation and mobility, changes in educational and recreational routines, disrupted family routines and relationships, access to health care, and more general uncertainty over the health and finances of family members and friends (Centers for Disease Control and Prevention [CDC], 2020). However, not all adolescents have developed mental health problems. The capacity to maintain well-being despite the odds is called resilience (Rutter, 2013) and understanding and fostering resilience to such challenges is therefore very important. Resilience is negatively associated with mental illness (e.g., Skrove, Romundstad & Indredavik, 2012), and positively associated with well-being (e.g., Satici, 2016). Understanding key aspects and factors of well-being in adolescents and young adults during the pandemic could be important to enhancing (post-pandemic) resilience among young people. In this study we sought to address this by investigating core aspects of well-being among adolescents of the three countries: the UK, Israel, and India. This knowledge can help recognise the extent to which young people across different countries have maintained positive mental health and well-being during a global set of challenges. In turn, this can guide development of universal and culture-specific intervention strategies to protect young people against mental health problems in future phases of the pandemic or beyond.

One approach to identifying core features of well-being is to use network analysis. Network analysis can represent the multi-component nature of constructs such as well-being through individual ‘nodes’ (items within a well-being scale). It also captures the dynamics between these components, by linking nodes together through ‘edges’ (partial correlations between items) (Kroeze et al., 2017). Within the network, some nodes are more strongly related to one another than other items, and appear as ‘clusters’ or sub-components. Each node can also be quantified through centrality indices; these inform the relative impact of that item on other items within the clusters and within the network more generally, such as its’ capacity to influence or activate another item (Borgatti, 2005). Identifying more central items could directly inform the targeting of these in interventions, reflecting a powerful way to enhance well-being. One well-researched measure of centrality is strength; the overall size of associations between an item and other items in the network. Using this approach, a prior study containing data from adults and young people in the UK identified positive self-perceptions (*I have been feeling good about myself; I have been feeling confident*) and positive mood (*I have been feeling cheerful*) as central items in well-being, with minimal age and gender effects (Stochl et al., 2018). Somewhat replicating these findings, positive mood, optimism and (task) engagement were identified as central well-being items in Chinese adolescents (Zeng, Peng, Peng-Hu, 2019). While intriguing, both studies were conducted pre-pandemic and as such are less informative regarding the maintenance of well-being in the face of adversity (i.e., resilience). Moreover, as there are only two studies, it is difficult to know the extent to which similarities and differences in results point to culturally-invariant ‘core’ features (positive mood) and country-specific core features (positive self-perceptions, engagement). Indeed, prior studies show cross-country differences in the endorsement of coping strategies in maintaining well-being (See & Essau, 2010).

The present study aims to extend these findings. First, we explored the core aspects of adolescent well-being during the first lockdown phase of the COVID-19 pandemic (beginning June, 2020), using the array of challenges posed by the pandemic as a natural stressor to tap resilient responses. Second, as the sociocultural, socioeconomic and historical background of countries could pervade young peoples' strategies for maintaining well-being in challenging situations, we collected data from Israel and India, and benchmarked these against network analysis we had recently conducted on young people from a third country, the UK (■■■■■ under review). The number of coronavirus cases in India, the UK, and Israel at the start of data collection were 236,184, 186,860, and 17,071, respectively, and were 879,466, 1,702,087, and 116,596 respectively at the end of data collection. Based on the above rationale, we sought to address the following specific questions:

1. What is the network structure of and which items are most central to the psychological well-being of young people in each country?
2. Are there variations in the clustering and centrality parameters across young people from India, Israel, and the UK?

We hypothesised that differences would be obtained in the network structure, items central to psychological well-being, as well as the clustering and centrality parameters of young people from India, Israel, and the UK.

Method

Participants and procedures

The study protocol for data collection across three sites was set up in response to the global COVID-19 pandemic, utilising an online survey design to understand the emotional impact of the pandemic in young people. Inclusion criteria were being able to read questionnaires presented in the language of that country (Hindi, Hebrew, English), and aged

12-18 in the India and Israel studies, and aged 12-25 in the UK study. However, to enable cross-country comparisons, data from 12-18 year old UK participants were only included in this study. The India sample comprised 310 adolescents, identified by circulating the information about the survey through social media. Although all participants were Hindi-speaking Asian-Indians, the survey link along with information sheets and consent forms were available bilingually in Hindi and English and participants could choose between languages. Participants aged 18 years provided informed consent; online parental consent followed by verbal confirmation over the phone was required for those aged <18 years. The Israeli sample comprised 306 adolescents, the majority (N=286, 93.46%) of whom were enrolled in an Israeli survey company (iPanel) and received compensation for participation (about 5 shekels, an equivalent of 1.5 USD). of the remaining participants (N=20, 6.4%) were recruited through snowballing. Similar to the India sample, Israeli participants aged 18 years and over provided their own consent to participate while parents consented to the participation of those aged 12-18 years. Information sheets and consent forms for Israeli participants were in Hebrew. Finally, the UK sample reported here comprised 1666 adolescents, recruited from schools and colleges, research advertisement websites, social media and charities. All participants aged ≥ 16 provided informed consent. For participants <16, informed assent/consent was provided by participants and their parent or guardian respectively. Participants were offered vouchers for their time to take part in this and subsequent follow-up surveys.

Participants in each country completed the same battery of measures (presented in English or translated into Hindi/Hebrew; see Appendix I and Appendix II for Hindi- and Hebrew-translated versions, respectively) administered through the online platform, Qualtrics. Ethical approval for the India study was received from the Institutional Ethics Committee, Institute of Medical Sciences, Banaras Hindu University, India (Ref:Dean/2020/EC/1975), for the Israel study from the University of Haifa Institutional Ethics Committee (Ref:368/20), and

for the UK study from King's College London Research Ethics Committee, UK (Ref:HR-19/20-18250). Of note, network analysis for UK participants aged 12-18 years have been presented elsewhere together with a comparison of data from 19-25 year olds (Wu et al., under review). Their inclusion here is primarily for cross-cultural comparison of the network results.

Well-being measure

The short version of the Warwick–Edinburgh Mental Wellbeing Scale (WEMWEBS), developed by Tennant and colleagues (2007) measures mental well-being across 7 items. Items are positively-worded (e.g., “I’ve been feeling optimistic about the future”) and are responded to on a 5-point scale (1=None of the time to 5=All of the time). Responses are summed to give a well-being score (ranging from 7 to 35), with higher scores indicating higher mental well-being. Internal consistency of the scale was 0.69 in Indian adolescents, 0.78 in UK and 0.81 in Israeli adolescents.

Statistical analysis

Network analysis quantifies links (“edges”) between observed items (“nodes”) of a measure; thus it informs the overall structure of items, clusters (“communities”) of items, and items that are more connected (“central”) (Costantini et al., 2015). All analyses were performed by various packages within the statistical software, R, version 1.2.5033-1 (Team, 2013). The Gaussian graphical model (GGM, Costantini et al., 2015), an undirected weighted network, was estimated based on partial Spearman correlations between observed variables by the R package “qgraph version 1.6.5” (Epskamp, Cramer, Waldorp, Schmittmann & Borsboom, 2012). To infer the characteristics of interest (i.e. relationships between nodes, clusters among nodes, the most central items), we evaluated the network structure using measures taken from graph theory (Müller, Reinhardt, & Strickland, 2012). When estimating the GGM, we

employed GLASSO regularisation (“graphical least absolute shrinkage and selection operator”, Tibshirani, 1996) to ensure the sparsity (fewer edges) of the model with the Extended Bayesian Information Criterion (EBIC; Chen & Chen, 2008) to select the best-fitting model.

These analyses yield 3 sets of information. First, GGMs were estimated and plotted for all participants and for each country. This enabled assessment of the overall network structures. Second, centrality indices representing the degree to which a node influences or can be influenced by other nodes were estimated for each item. We focused on strength only as this was stable across all of the present analyses. Strength suggests how strongly and frequently a node is directly associated (has edges) with other nodes. Third, communities within the networks were detected using the Louvain algorithm (Rubinov & Sporns, 2011) on edge weights, which identifies nodes that cluster together using “NetworkToolbox version 1.4.0” (Christensen, 2018). The Louvain algorithm optimises modularity, defined as the comparison between the edges’ density of a community/cluster and edges’ density outside this community/cluster, through moving each node to different communities/clusters (Blondel, Guillaume, Lambiotte, & Lefebvre, 2008). This algorithm has been used in previous studies and shown good performance (Miers et al., 2020).

We conducted network analysis for each country separately before performing network comparison analyses with Bonferroni correction conducted on the global strength of the networks. Global strength is the total sum of all edge weights (partial Spearman correlations) and reflects how tightly linked the entire network is. Group differences were also assessed on the centrality index – strength – across the different groupings with 5000 iterations using “NetworkComparisonTest version 2.2.1” (van Borkulo et al., 2016). To mitigate against potential sample size limitations, we applied bootstrapping procedures to enhance the reliability of network parameters (Epskamp, Borsboom & Fried, 2018) using “bootnet version 1.4.3” (Epskamp et al., 2018; See *Supplementary* material). The 95% confidence intervals (CI)

of edge weights were obtained through a bootstrapping method, involving repeatedly estimating a model under sampled data and the statistic of interest (Team, 2013). To investigate stability of centrality indices, correlation stability (CS) coefficients were calculated by case dropping bootstrap methods. Here, the centrality measures are recalculated for different sub-portions of the data after dropping a random percentage of cases. The CS coefficient is defined as the amount of cases that can be dropped while still maintaining a high correlation ($>.7$) with the original centrality estimate (Epskamp et al., 2018). This coefficient should not drop below 0.25 and ideally be above 0.5 to justify robust interpretation of centrality indices.

Results

Age, gender ratio and well-being score of participants from each country are presented in Table 1. Male and female participants from India showed no significant difference in age, $t(308)=.84$, $p=.40$ (Mean age (SD)_{males}=15.60(1.98); Mean age_{females}=15.78 years; SD_{females}=1.87). Nor were there age differences between males and females in the Israeli sample, $t(304)=.50$, $p=.62$ (Mean age_{males}=15.37 years, SD_{males}=1.84 and Mean age_{females}=15.26 years, SD_{females}=1.78). In the UK sample, male participants (Mean age=15.28 years; SD=2.02) were significantly younger than female participants (Mean=15.59 years; SD=1.94), but this group difference was small, $t(1664)=3.01$, $p=.003$, $d=.15$. Across countries, the three groups varied in age, $F(2, 2245)=32.99$, $p<.001$, $\eta^2=.03$, driven by older participants in the Israeli sample compared to the other samples, mean difference_{Israel-UK}=0.96, $p<.001$, CI [0.68, 1.24]; mean difference_{Israel-India}=0.75, $p<.001$, CI [0.39, 1.11]. There were more female participants in the UK sample compared with the other samples, $\chi^2(2)=42.09$, $p<.001$. Mean well-being scores also varied across groups, $F(2, 2197)=54.78$, $p<.001$, $\eta^2=.05$, where well-being scores of the UK participants were significantly lower than those of the Indian and Israeli participants, mean difference_{UK-india}=1.89, $p<.001$, CI [1.2, 2.58]; mean difference_{UK-Israel}=2.72, $p<.001$, CI [2.01,

3.42, but there was no significant difference between Indian and Israeli samples, mean difference_{India-Israel}=0.83, $p=.08$, CI [-0.07, 1.73].

Well-being networks for each country and across countries

For visual comparability, Figure 1 shows the estimated average layout of each network. Each network showed good or moderate levels of stability (Table 1), suggesting interpretations should be made with caution. For each network, all nodes were positively connected and no node was isolated (Figure 1). Visual inspection of the number and composition of clusters in the network varied across countries. As reported elsewhere (Wu et al., under review) the UK sample network comprised two clusters. The first cluster included: items 1 (*“feeling optimistic about the future”*), 2 (*“feeling useful”*), and 6 (*“feeling close to other people”*), while the second included items 3 (*“feeling relaxed”*), 4 (*“dealing with problems well”*), 5 (*“thinking clearly”*) and 7 (*“able to make up my own mind about things”*). The network of the Israeli sample was also composed of two similar clusters with exception to item 3 (*“feeling relaxed”*) which cohered with the first rather than second cluster (Figure 1). In contrast, the network of the Indian sample consisted of three clusters. The first included items 1 (*“feeling optimistic about the future”*), 2 (*“feeling useful”*) and 3 (*“feeling relaxed”*); the second cluster consisted of items 4 (*“dealing with problems well”*) and 5 (*“thinking clearly”*); while the last consisted of items 6 (*“feeling close to other people”*) and 7 (*“able to make up my own mind about things”*). Of note, due to there being significantly more females in the UK sample, we also repeated analyses in gender-matched country groups, yielding similar findings.

Network comparisons across countries revealed that the global strength varied significantly. Global strength of the Indian sample was lower than both the UK sample, $p=.004$, and Israeli sample, $p=.02$, but the difference of global strength between the UK sample and the Israeli sample did not reach significance level, $p=.06$, suggesting similar network structures

between UK and Israeli samples. Based on the visual comparison of the networks, the edge weights show similar findings with that of the global strength, indicating that the UK sample and the Israeli sample shared some characteristics of the well-being networks. However, comparison tests do not show many differences across the three networks, revealing significant differences only in the edge weight of item 1 and 3 between the UK and Israeli samples (0.04 for UK, 0.19 for Israel, $p=.05$) and the edge weight of item 3 and 4 between the UK and Indian samples (0.22 for UK, 0 for India, $p<.001$). Again, we repeated the analyses in gender-matched country samples, with similar findings to the unmatched samples for edge weight differences.

Well-being centrality indices for each country and across countries

Centrality indices of each network showed differences across countries. UK and Israeli networks both centred on item 4 (“*dealing with problems well*”) but item 5 (“*thinking clearly*”) was also central in the UK network (Figure 2). Data from Indian participants show a different central item (item 2, “*feeling useful*”) (Figure 2), suggesting a potentially different focus of well-being. Cross-country comparison tests show that the strengths of item 3 and 4 (“*feeling relaxed*”, “*dealing with problems well*”) in the Indian sample were respectively lower than those of the UK, $p_{item3}=.01$ and $p_{item4}=.01$ and Israeli samples, $p_{item3}=.03$ and $p_{item4}=.01$. The strength of item 5 also differed between the UK and Indian samples, $p=.001$, but not between the Indian and Israeli samples, $p=1$. All other items were insignificantly different across countries. Again, similar findings were obtained when centrality analyses were repeated using gender-matched country groups.

Discussion

The aim of the present study was to explore the items playing a central role in the psychological well-being of young people in three countries (India, Israel, UK) during the COVID-19 pandemic. To the best of our knowledge, such a cross-cultural investigation into the

central aspects of youth resilient responses during the coronavirus pandemic has not been undertaken. To address this objective, network analysis was used to identify central items and clusters on a widely used well-being measure, which includes affective and functional (largely cognitive processing) aspects of well-being. Using node strength as the centrality index, data from the UK and Israel pointed to item 4 (*I've been dealing with problems well*) as a central item, with UK participants also indicating item 5 (*I've been thinking clearly*) as an influential item. In contrast, data from India participants indicated item 2 (*I've been feeling useful*) as the most connected item. Clustering of the well-being items also varied across countries. While UK and Israel showed high levels of similarity in their item clustering, with both countries implicating two clusters (one broadly affective, one broadly functional, around cognitive processing), India data pointed to three clusters. Finally, it is noteworthy that there was greater similarity in edge weights of the UK and Israeli samples to one another, and there was significantly lower global strength of the Indian sample network compared to that of the UK and Israel.

Differences in central well-being items between the countries could relate to shared sociocultural values between UK and Israel that differ to those endorsed by Indian youth. The UK and Israel are considered high-income countries but also historically to adopt more individualistic social values (Hofstede Insights, 2017). Young people growing up in these countries are more likely to endorse independence over inter-dependence in their self-construals. Problem-solving and for UK participants only, clarity of thinking of the individual were identified as central (more influential) features of psychological well-being. In contrast, India, is considered a collectivist society where adolescents and young adults still live in joint-family systems (Mathur, 2018). Their well-being was therefore more likely to be characterised by '*feeling useful*'—possibly manifesting through prosocial behaviour during the lockdown in terms of helping their family in household activities and finances (UNICEF India, 2020). This

finding is consistent with that reported in an earlier study of well-being in another collectivist culture- China (Zeng et al., 2019), which showed that engagement (being useful) is an important component of well-being among Chinese adolescents. Further, the finding of no gender differences in the centrality of items is consistent with a previous study of well-being involving UK participants (Stochl et al., 2018). Compared to studies conducted pre-pandemic which highlighted the centrality of positive affect in well-being networks (Stochl et al., 2019; Zeng et al., 2019), our multi-national data collected during the pandemic indicated the centrality of not just affective but also cognitive components in well-being networks, depending upon culture.

Our data also speak to some cultural differences in clusters of well-being items. Items clustering together in network analysis are more strongly inter-connected, which may mean they are activated together. The UK and Israel samples show two highly similar clusters. For the UK, cluster 1 reflected the affective component of well-being while cluster 2 reflected the cognitive aspect of well-being. Israeli participants show the same clustering except for item 3- *“feeling relaxed”* which, unlike the UK sample, was in cluster 1. On the other hand, for India, three clusters were identified, where cluster 1 comprised items 1, 2 and 3; cluster 2 comprised items 4 and 5, while cluster 3 comprised items 6 and 7. Again, the cross-cultural differences in clustering of items could be explained by individualism-collectivism differences between countries. While all three countries showed two distinct clusters of affective and cognitive components of well-being, an additional cluster in India shows that collectivist cultures view decision making (*“able to make up my own mind about things”*) as highly interconnected with *“feeling close to other people”*. This suggests that in a collectivist culture decision making is not an individualistic task but is associated with having close relationships with others. This has previously been reported in collectivist cultures, where even day-to-day decision making involves others, while in individualistic cultures (such as UK and Israel), decision making is

focussed on achieving personal goals rather than accommodating goals of others (Yates & de Oliveira, 2016). This collectivist cultural practice of shared decision making may have heightened during the pandemic-related lockdown, where living in closer proximity than normal and the prevailing uncertainty may have lead to even small decisions involving other family members. Overall, the striking similarity in the item-clustering of well-being across the three countries suggests both universal and culture-specific aspects of well-being.

There are several limitations to our findings. First, caution should be exercised in interpreting the centrality indices for the Israeli and the India sample, both of which show moderate levels of stability (.44) which fell slightly short of the recommended criteria of .50 (Epskamp et al., 2018). Thus, the robustness of these findings need to be verified in future investigations. Relatedly, we relied on node strength as the measure of centrality, but other measures such as closeness (an index of the lengths of paths from any one node in the network to itself; Costantini et al., 2015) and betweenness (the number of shortest paths passing through a specific node; Bringmann et al., 2019) can be used. By only using one index, some key features of the network might be lost (Martin, Zhang & Newman, 2014). However, as these indices were not reliably estimated from the current dataset, they were not presented here. The present study utilised convenience sampling collected online, limiting generalisability of findings. Given that the study is cross-sectional, it is not possible to know whether the findings are truly indicative of well-being or resilience during the pandemic, as we did not have a pre-pandemic measurement of well-being. Another limitation is the use of a single, short measure of psychological well-being, which limits the extent to which different dimensions of well-being could be captured. Our findings ought to therefore be corroborated in future studies using multi-dimensional measures of well-being. Lastly, some generalizability and replicability issues in network analysis methodology have been reported (Forbes et al., 2017) and therefore caution needs to be exercised in interpreting and implementing the findings.

Our findings concerning which aspects of well-being were considered most influential and connected with other aspects could have implications for identifying important intervention targets for designing interventions to increase resilience among young people. Since psychological well-being and mental illness are considered to exist on a continuum (Böhnke & Croudace, 2016), interventions targeting improvements in well-being would positively impact symptoms of mental illness (such as stress, anxiety, depression) which have been reported in adolescents and young adults both pre and during the COVID-19 pandemic (Chen et al., 2020; Ellis et al., 2020; Ozamiz-Etxebarria et al., 2020). These findings also suggest that culture-type (individualistic vs. collectivistic) may have an important bearing on the key elements of resilience. Nevertheless, the present findings strongly support cross-cultural similarities in well-being structure rather than differences.

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