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A network analysis of the associations between COVID-19-related variables and health across sex, age and educational levels among Ghanaian youths

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The COVID-19 pandemic has had far-reaching impacts on global health, affecting not only physical well-being but also exacerbating mental health issues. The present study investigated the associations between COVID-19-related variables and health outcomes across different sex, age, and education levels. The cross-sectional survey study was conducted from June to August 2022, comprising 1,326 participants aged 12 to 28 years in Ghana. Participants completed psychometric measures assessing fear of COVID-19, psychological distress, perceived stigma, self-stigma, preventive behaviors, believing COVID-19 information, vaccination acceptance, and quality of life. Network analysis indicated that COVID-19-related stress was positively associated with fear of COVID-19, psychological distress, and COVID-19-related self-stigma. The fear of COVID-19 was positively associated with preventive COVID-19 behaviors, COVID-19-related self-stigma, and believing COVID-19 information, while psychological distress was positively associated with COVID-19-related self-stigma but negatively associated with both physical and mental quality of life. Physical quality of life was negatively associated with COVID-19-related perceived stigma and COVID-19 vaccine acceptance. These network structures varied across sex, age, and educational levels. COVID-19-related stress had the highest centrality across four indices. In sum, the present study highlighted the interconnectedness of COVID-19-related variables and health factors among young people in Ghana. COVID-19-related stress appeared to be a pivotal determinant of psychological well-being. Stress related to the COVID-19 pandemic served as a key determinant of psychological well-being. The differences in network structures across sex, age, and education levels highlighted the importance of tailored health interventions. Further research employing longitudinal study designs and targeting

diverse populations are needed to observe the dynamic associations between health-related variables over time.

Keywords Mental health, COVID-19, Well-being, Network analysis, Young population

Abbreviations

COVID-19	Coronavirus disease 2019
KNUST	Kwame Nkrumah University of Science and Technology
FCS	Fear of COVID-19 Scale
BCIS	Believing COVID-19 Information Scale
SSS	Self-Stigma Scale from COVID-19
CSS	COVID-19 Stress Scale
COVID-VA	Motors of COVID-19 Vaccination Acceptance
PSS	Perceived Stigma Scale from COVID-19
SF-12	Short Form-12 Health Survey
SF_PCS12	Short Form-12 Health Survey physical health domain
SF_MCS12	Short Form-12 Health Survey mental health domain
DASS-21	Depression, Anxiety, and Stress Scale-21
PCIBS	Preventive COVID-19 Infection Behaviors Scale
EBICglasso	Extended Bayesian information criterion graphical least absolute shrinkage and selection operator
CI	Confidence interval
JHS	Junior high school
SHS	Senior high school

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The coronavirus disease 2019 (COVID-19) pandemic has had wide-ranging effects on global health, extending far beyond its immediate impact on physical mortality[1–3]. The pandemic led to profound psychosocial consequences, generating heightened levels of stress, fear, and stigma that affected individuals' quality of life and psychological well-being[4,5]. In Ghana, although up-to-date public data on confirmed COVID-19 cases is no longer routinely available as of 2025, the pandemic continues to have a significant impact on all age groups including adolescents and emerging adults[4,6]. As a result, governments and healthcare professionals continue to monitor and manage the prolonged effects of the pandemic[7], and understanding how COVID-19-related factors intersect with broader health outcomes has become increasingly important[8].

COVID-19-related variables are essential for understanding public responses to the pandemic[7,9–12]. These factors, along with individuals' perceptions of COVID-19 information and COVID-19 preventive behaviors, may have a substantial influence on individuals' physical and mental health[13]. Concurrently, psychological distress and health-related quality of life serve as vital indicators of how effectively individuals managed the pandemic's ongoing stressors[9]. This complex interplay between these COVID-19-related variables and general health is likely moderated by demographic factors such as sex, age, and educational attainment[14,15].

The extant literature suggests that sociodemographic characteristics significantly influence the experience and perception of COVID-19-related stressors[16]. Previous studies indicated that females had higher levels of fear and psychological distress compared to males during the pandemic[17,18], while younger individuals exhibited more pandemic-related anxiety compared to older adults[19]. Additionally, educational levels can impact how individuals process information regarding COVID-19, influencing their acceptance of vaccines, engagement in preventive behaviors, and overall psychological resilience[20]. More specifically, a study conducted among Ghanaian youth found that males reported higher levels of stress compared to females. The authors suggested that sex may play a pivotal role in moderating the psychological impact of the pandemic among this population[4]. However, the associations between these COVID-19-related and health variables across different demographic groups such as sex, age, and education levels are still unclear, particularly from a network analysis perspective, which may provide a more holistic view of these relationships. It is likely that females, younger individuals, and those with lower education levels were more vulnerable to psychological distress during the pandemic.

Network analysis, as a statistical analysis, offers a powerful methodological approach for examining associations between variables in a comprehensive way[21]. It provides a holistic view of the interrelationships between COVID-19-related factors, making it easier to understand how these factors affect people's health and well-being. Based on this approach, the rationale of the present study was to clearly map how key COVID-19-related variables are associated with each other and other health variables including psychological distress, and physical and mental health quality of life using network analysis. Such findings will enable clinicians and researchers to clearly visualize and understand how the various COVID-19-related variables are connected and how they are associated with an individual's health and quality of life. Although the COVID-19 pandemic is now over, the virus continues to mutate, and newer influenza viruses have emerged[22]. Therefore, the findings will provide further insight to clinicians and researchers as to how psychosocial experiences related to infectious diseases are associated with quality of life, and aid prevention across different sexes, ages, and levels of education.

The present study represented an initial effort to investigate COVID-19-related outcomes among young Ghanaians, using network analysis to examine the roles of age, sex, and education level. It aimed to explore the interrelationships among key COVID-19-related variables, including stress, fear, stigma, vaccination acceptance, and preventive behaviors, alongside health outcomes (i.e., health-related quality of life, psychological distress [depression, anxiety, and stress]), and to ascertain the variable most central to these associations. The specific objectives were to (i) examine the associations between the variables, (ii) ascertain the variables that have the highest centrality indices, and (iii) examine group differences (i.e., sex, age, and educational level) in the network structures. The present study's research questions were: (i) Are there associations between the variables in the network structures? (ii) Which variables have the highest centrality indices in the network structures? and (iii) Are there group differences (i.e., sex, age, and educational level) in the network structures? Although a previous study has been published based on part of the present dataset[8], the sample sizes and objectives of the two studies were completely different. More specifically, 471 participants from the previously published study were used in the present study (i.e., approximately one-third of the current sample). Therefore, there were significant differences in both the samples and purposes of the two studies. Also, the novelty of the present study was to use the network analysis to examine the structure and centrality of COVID-19-related variables among youth population in Ghana. The findings may provide contributions to the understanding of how COVID-19 affects young people in Ghana and practical implications for mental health professionals in designing tailored psychological interventions for young Ghanaians who have experienced pandemic-related challenges.

Methods

Participants and procedure

The present study, employing a cross-sectional survey design, recruited a total of 1,326 participants from junior high schools, senior high schools, and Kwame Nkrumah University of Science and Technology (KNUST) in Ghana. The inclusion criteria were being (i) students at junior high, senior high or university (i.e., undergraduates), and (ii) aged 12 to 29 years. The number of participants needed for the present study was based on the Monte Carlo-based method for sample size estimation in the context of cross-sectional network models where a sample size of above 854 was needed for networks with moderate to high complexity including sensitivity ≥ 0.6 with 80% power[23]. Data collection took place from June to August 2022, with participants completing the surveys in English.

Junior high school (JHS) and senior high school (SHS) participants were selected from two junior high schools (six classes per school) and two senior high schools (nine classes per school) in the Kumasi metropolis using convenience sampling. After receiving the approvals from the schools, in-person data collection dates were scheduled. On the day of data collection, a teacher (i.e., academic head or housemaster/headmistress) was assigned to introduce the research team to the classes. Only the research team remained in the class during the data collection. Students were informed about the study, and research assistants provided consent forms for those who were willing to be part of the study (i.e., convenience sampling was used). For participants under 18 years old, both guardians and students signed the consent forms. Research assistants were present to clarify any unclear questions during the data collection, although very few students (less than 10%) sought help. Out of the 1,100 students who initially volunteered, 817 completed the questionnaire (74.27% response rate). However, based on the inclusion criteria, only 760 participants (69.09% response rate) were used for the data analysis. Data collection occurred over four days (one day at each school), with an absentee rate of approximately 1.5%. As a token of appreciation, participants received pens inscribed with "School of Medicine, KNUST" and a debriefing session was held following data collection.

At KNUST, the researchers sought permission from lecturers to collect data during scheduled classes. On the scheduled dates, the researchers and their team provided detailed information about the study to the potential participants and those willing to be part of the study provided their written informed consent (i.e., a convenient sampling technique was used). Four and two lectures (five days for all data collection) were used for the undergraduates and postgraduates (although some postgraduate participants who completed the questionnaire were in informal meetings), respectively. A total of 600 students out of 840 completed the questionnaire (71.4% response rate). However, based on the inclusion criteria, only 566 participants (67.38% response rate) were used for the data analysis. Upon completion, participants received university-branded pens as tokens of appreciation. All procedures strictly adhered to the ethical guidelines of the Helsinki Declaration, ensuring confidentiality, anonymity, and participants' right to withdraw from the study without consequences. Ethical approval was obtained from the KNUST Ethics Committee (IRB ref: CHRPE/AP/203/22).

Measures

Fear of COVID-19 Scale (FCS)

This seven-item scale[24] was used to assess participants' fear of COVID-19. Items (e.g., *"I am afraid of losing my life because of COVID-19"*) are rated on a five-point Likert scale, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*). The total score ranges from 7 to 35, with higher scores indicating greater levels of COVID-19 fear. In the present study, the scale had very good internal consistency (omega=0.88).

Believing COVID-19 Information Scale (BCIS)

This six-item scale[25] was used to assess participants' belief in COVID-19 information from six sources including *LINE*, *Facebook*, online news, television, and newspapers. Items (e.g., *"How much do you believe in COVID-19 information on television?"*) are rated on a five-point Likert scale, from 1 (*strongly disbelieve*) to 5 (*strongly believe*). The total score ranges from 6 to 30, with higher scores indicating greater belief in COVID-19 information. In the present study, the scale had excellent internal consistency (omega = 0.92).

Self-Stigma Scale from COVID-19 (SSS)

This nine-item scale[26] was used to assess participants' COVID-19-related self-stigma. Items (e.g., *"I feel uncomfortable because I have suspicious symptoms of COVID-19"*) are rated on a four-point Likert scale from 1 (*strongly disagree*) to 4 (*strongly agree*). The mean score ranges from 1 to 9, with higher mean score indicating greater COVID-19 self-stigma. In the present study, the scale had excellent internal consistency (omega = 0.93).

COVID-19 Stress Scale (CSS)

This 36-item scale[27] was used to assess COVID-19-related stress across five dimensions comprising danger and contamination fears, socio-economic fears, xenophobia, compulsive checking, and traumatic stress symptoms. Items (e.g., *"I am worried about catching the virus"*) are rated on a five-point Likert scale from 0 (*not at all*) to 4 (*extremely*). The total score ranges from 0 to 144, with higher scores indicating greater levels of COVID-19-related stress. In the present study, the scale had very good internal consistency (omega = 0.89).

Motors of COVID-19 Vaccination Acceptance (COVID-VA)

This 12-item scale[28–30] was used to assess participants' acceptance of the COVID-19 vaccine. Items (e.g., *"It is important that I get the COVID-19 jab"*) are rated on a seven-point Likert scale from 1 (*strongly disagree*) to 7 (*strongly agree*). The total score ranges from 12 to 84, with higher scores indicating greater levels of vaccine acceptance. In the present study, the scale had excellent internal consistency (omega = 0.9).

Perceived Stigma Scale from COVID-19 (PSS)

This eight-item scale[26] was used to assess the perceived stigma related to COVID-19. Items (e.g., *"People act as if they are afraid of you"*) are rated on a binary scale (Yes = 1, No = 0). The total score ranges from 0 to 8, with higher scores indicating greater levels of perceived stigma. In the present study, the scale had excellent internal consistency (omega = 0.91).

Short Form-12 Health Survey (SF-12)

This 12-item scale[31] was used to assess health-related quality of life across eight domains of physical health (SF-PCS12) and mental health (SF-MCS12). The scale is a widely used tool for assessing overall health-related quality of life[32]. A sample item is *"Did you have a lot of energy?"* (vitality). Higher scores indicate better health. In the present study, the scale had good internal consistency (omega = 0.78).

Depression, Anxiety, and Stress Scale-21 (DASS-21)

This 21-item scale[33] was used to assess psychological distress across three dimensions: depression, anxiety, and stress (seven items per subscale). Items (e.g., *"I found it hard to wind down"*) are rated on a four-point Likert scale from 0 (*did not apply to me at all*) to 3 (*applied to me very much, or most of the time*). The total score ranges from 21 to 63, with higher scores indicating greater levels of distress[34]. In the present study, the scale had excellent internal consistency (omega = 0.94).

Preventive COVID-19 Infection Behaviors Scale (PCIBS)

This five-item scale[29] was used to assess COVID-19 infection prevention behaviors based on World Health Organization recommendations. Items (e.g., *"I stay home more when I feel unwell"*) are rated on a five-point Likert scale from 1 (*almost never*) to 5 (*almost always*). The total score ranges from 5 to 25, with higher scores indicating more frequent engagement in preventive behaviors. In the present study, the scale had good internal consistency (omega = 0.75).

Data analysis

The data were analyzed using descriptive statistics to summarize participants' characteristics. To assess the data distribution, the Mardia test was used to examine multivariate normality for variables included in the subsequent network analysis. Pearson correlations were used to examine relationships between variables. Network analysis was used to visualize the associations between variables[35]. The network analysis procedure followed the following steps: (i) data preparation: screening data for missing values and applying listwise deletion; (ii) network estimation: applying EBICglasso algorithm with tuning parameter $\lambda = 0.5$ to estimate partial correlations between all variable pairs with regularization; (iii) network visualization: positioning nodes using Fruchterman-Reingold algorithm, scale edge thickness by correlation strength, and color edges (blue for positive, red for negative correlations); (iv) subgroup analysis: stratifying data by different groups, then repeating

Variable	Category	Mean (SD)	*n* (%)
Age years	—	18.15 (2.91)	
Sex	Male	—	710 (53.5)
	Female	—	616 (46.5)
Education	Junior high school	—	291 (21.9)
	Senior high school	—	469 (35.3)
	Undergraduate students	—	566 (42.7)
Accommodation	Day	—	634 (47.8)
	Boarding	—	671 (50.6)
Physical Quality of Life	—	43.21 (8.92)	—
Mental Quality of Life	—	39.53 (9.98)	—
Fear of COVID-19	—	19.41 (6.28)	—
COVID-19 Perceived Stigma	—	4.08 (2.86)	—
Self-stigma from COVID-19	—	2.22 (0.78)	—
Believing COVID-19 Information	—	20.58 (5.01)	—
COVID-19 Vaccination Acceptance	—	46.88 (16.29)	—
Psychological Distress	—	16.31 (13.42)	—
COVID-19 Stress	—	1.45 (0.85)	—
COVID-19 Preventive Behaviors	—	16.34 (4.00)	—

Table 1. Participant characteristics ($N = 1{,}326$).

	1	2	3	4	5	6	7	8	9	10
1. Physical Quality of Life	—									
2. Mental Quality of Life	−0.05	—								
3. Fear of COVID-19	−0.12***	−0.07*	—							
4. COVID-19 Perceived Stigma	−0.15***	−0.01	0.04	—						
5. Self-stigma from COVID-19	0.01	−0.06*	0.31***	−0.06*	—					
6. Believing COVID-19 Information	0.05	0.03	0.27***	−0.02	0.20***	—				
7. COVID-19 Vaccination Acceptance	−0.30***	−0.09*	0.01	0.11***	−0.05	−0.04	—			
8. Psychological Distress	−0.12***	−0.36***	0.20***	0.04	0.19***	−0.01	0.03	—		
9. COVID-19 Stress	−0.15***	−0.08*	0.49***	0.04	0.33***	0.17***	0.02	0.37***	—	
10. COVID-19 Preventive Behaviors	−0.03	0.05	0.21***	−0.04	0.08*	0.20***	−0.01	0.06*	0.18***	—

Table 2. Pearson correlations (p-value) matrix of the studied variables. Note: $^{*}p < 0.05$; $^{***}p < 0.001$.

network estimation and visualization for each subgroup; and (v) comparison: examining network differences across subgroups.

The network analysis was conducted using JASP software (version 19.3). The network analysis module in JASP is based on the bootnet package[36] for network estimation and stability analysis, while network visualizations were generated using the qgraph package[37].

Centrality measures – betweenness (connectivity), closeness (distance centrality), strength (degree centrality), and expected influence (a node's overall impact on the network, including activation, persistence, and remission) – were calculated to assess the importance of each node[21,35]. Before reporting these centrality results, their accuracy was evaluated by calculating 95% confidence intervals (CIs) from parametric bootstrapped samples, with narrower CIs indicating higher precision in the edge estimates. For the network analysis figures (provided in the Results section), blue lines indicate positive associations whereas brown lines indicate negative association. The thicker denser colored lines indicate stronger association between the two circles[35]. All statistical significances were set at $p < 0.05$.

Results

A total of 1,326 participants, aged between 12 and 28 years, were included in the present study (see Table 1). The Mardia test results indicated significant violations of multivariate normality. Both multivariate skewness (statistic = 845.34, $p < 0.001$) and multivariate kurtosis (statistic = 7.11, $p < 0.001$) were highly significant, demonstrating substantial departures from multivariate normal distribution.

Table 2 shows the Pearson correlation matrix. COVID-19-related stress demonstrated small to moderate correlations with most variables, while COVID-19 prevention behaviors showed minimal or non-significant correlations with other variables. The EBICglasso Network Edge Weights Matrix (Table S1 in the Supplementary Materials) showed notably different patterns from the Pearson correlations, with most values differing

substantially. This is expected because EBICglasso estimates partial correlations that control for the influence of all other variables in the network.

The network analysis of the variables is visualized in Figs. 1, 3, 4, and 5 for the entire participant sample, and by sex, age, and educational level. The accuracy of the edges in the network's centrality was confirmed by 95% CIs using parametric bootstrapped samples, indicating that most of the CIs of edge estimates did not include zero (Figures S1–4 in the Supplementary Materials). Figure 1 shows the entire participant sample. COVID-19-related stress was directly and positively associated with fear of COVID-19, psychological distress, and COVID-19-related self-stigma. Psychological distress was positively associated with COVID-19-related self-stigma but negatively associated with both physical and mental quality of life.

The central index is shown in Fig. 2. The results demonstrated that COVID-19-related stress had the highest centrality across four indices. Fear of COVID-19 also had relatively higher centrality. Among these nodes, COVID-19-related perceived stigma had a relatively lower impact on the structure.

The network analysis for males and females showed several similarities and differences in their associations between variables (Fig. 3). In both sexes, COVID-19-related stress was directly and positively associated with fear of COVID-19, psychological distress, and COVID-19-related self-stigma, while fear of COVID-19 was positively associated with COVID-19 prevention behaviors, COVID-19-related self-stigma, and believing COVID-19 information. Additionally, psychological distress was negatively associated with mental quality of life. Physical quality of life was negatively associated with COVID-19 vaccination acceptance and COVID-19-related perceived stigma for both males and females. Notable differences were observed in the associations of psychological distress and COVID-19 prevention behaviors with other variables.

In comparing the network analysis of participants under 18 years old and those 18 years and older (Fig. 4), several similarities and differences were observed. In both age groups, COVID-19-related stress was directly and positively associated with fear of COVID-19, psychological distress, and COVID-19-related self-stigma, while psychological distress was negatively associated with mental quality of life. Fear of COVID-19 was positively associated with believing COVID-19 information, COVID-19 prevention behaviors, and COVID-19-related self-stigma in both Fig. 4a and b. However, notable differences were found in the associations of COVID-19-related perceived stigma, psychological distress, and physical quality of life with other variables. For participants aged 18 years and older, physical quality of life was directly and negatively associated with COVID-19-related perceived stigma and psychological distress. However, this association was not observed among participants under 18 years of age. Moreover, the associations between COVID-19-related perceived stigma and other variables showed opposite directions between the two groups: among participants under 18 years, perceived stigma was negatively associated with self-stigma and COVID-19-stress, while among participants 18 years and older, the associations were positive.

Figure 5 shows the overall network structures, which were largely consistent across the three educational levels. This suggests that the relationships between various factors are similar, irrespective of educational attainment. Upon closer examination of the differences between the three educational levels, the main variation

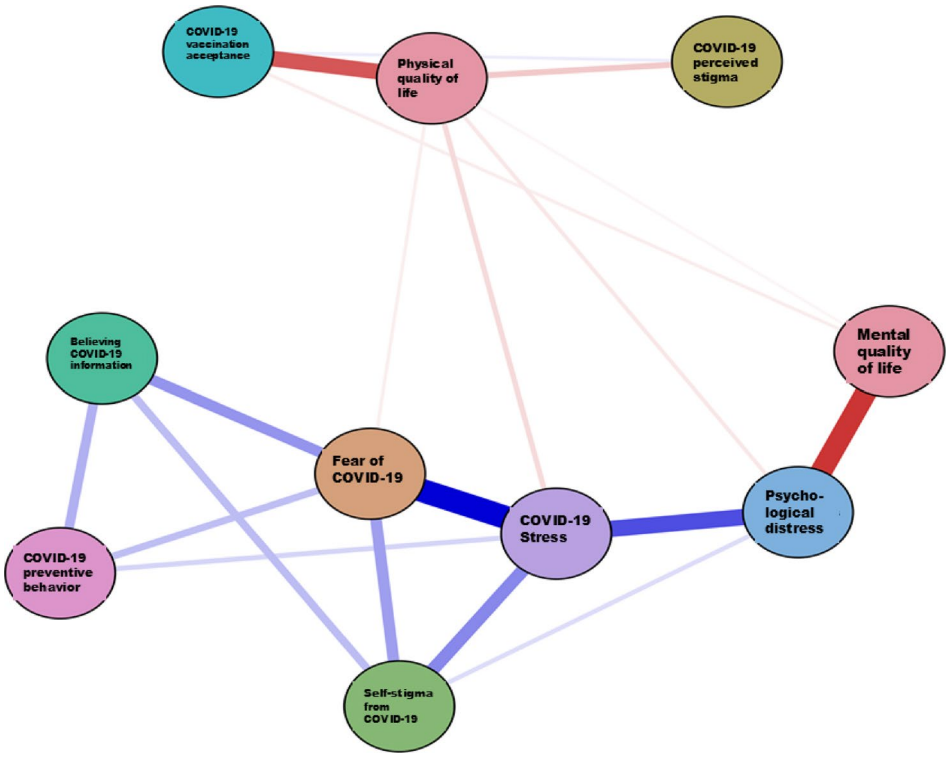

Fig. 1. Network analysis for all participants.

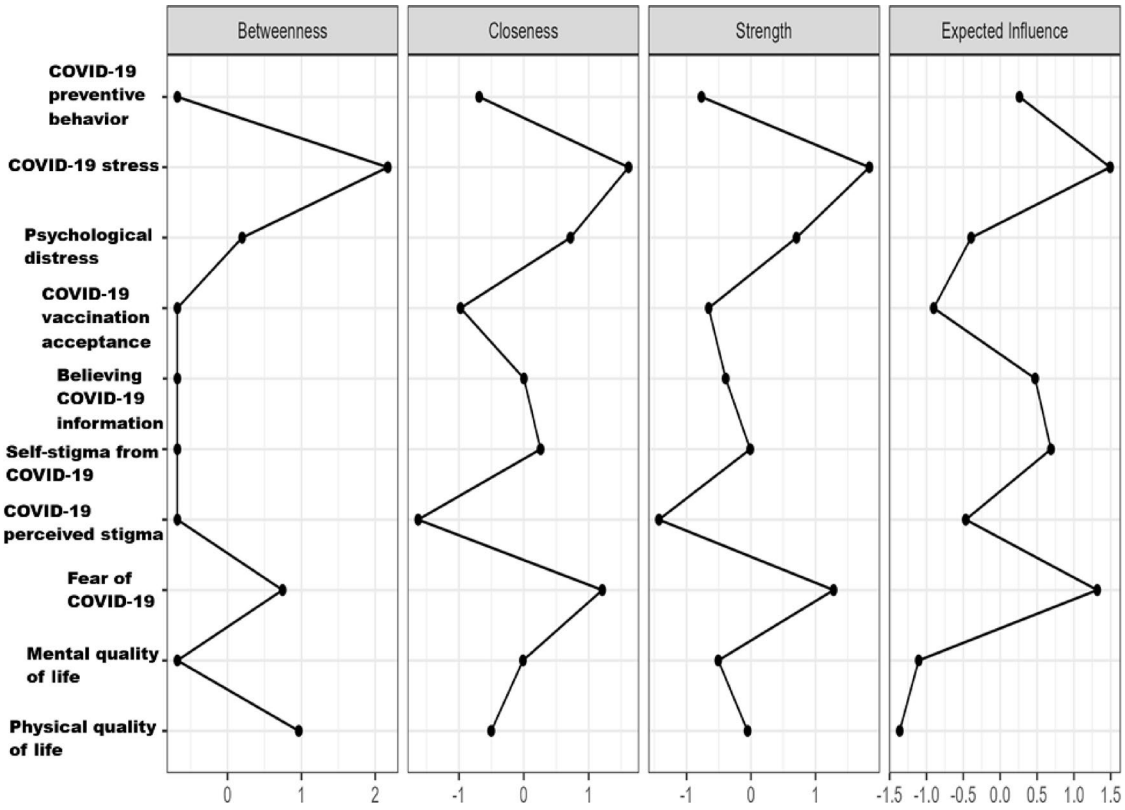

Fig. 2. Centrality index of the network structure (total sample).

was in the association between physical quality of life and psychological distress. Among junior high school and senior high school students, no association was observed between these variables, while among university and postgraduate students, a substantial negative association was observed.

Discussion

The present study examined the associations between key COVID-19-related variables among a sample of 1,326 Ghanaian participants aged 12 to 28 years. The findings provided important insights into how these factors interacted across different subgroups, including sex, age, and educational level. The network analysis identified key COVID-19-related variables that are associated with psychological distress, physical and mental health, and COVID-19 vaccine acceptance.

The network analysis showed that COVID-19-related stress had the highest centrality across the variables, indicating its crucial role in the interplay between psychological distress, COVID-19 fear-related concerns, and health outcomes. This finding supports prior findings highlighting that stress specific to COVID-19 has a central role in mental and physical health[38,39]. COVID-19-related stress comprised anxiety related to fear of infection, economic instability, fear of being stigmatized, and uncertainty about the future[5]. These factors may lead to unstable mental health or exacerbate existing mental health conditions, resulting in psychological distress. The findings also suggested that COVID-19 stress not only affected mental health stability, but also impacted physical well-being. Consequently, this may negatively impact both physical and mental health including disrupting sleep patterns and weakening immune function[40]. Therefore, effective interventions aimed at managing stress and promoting overall well-being during pandemics are much needed.

In contrast to earlier studies, which often placed more emphasis on perceived stigma as a central factor in mental health outcomes[41,42], the present study's findings highlighted COVID-19-related stress as having a more direct influence. This discrepancy may be attributed to the specific population surveyed in the present study. Young and educated individuals, perhaps experienced COVID-19 stress more directly in their daily lives, including disruption of education, financial instability, and family tension, prioritizing its immediate impact over other factors[43,44]. This shift in focus from the perception of stigma to stress is an important contribution to the present study.

Additionally, psychological distress showed a negative association with both physical and mental quality of life, reinforcing prior studies that have emphasized the adverse effects of psychological distress on both physical and mental health[45]. These findings are consistent across various populations[46,47], indicating that psychological distress remains a pivotal predictor of poorer health outcomes.

Both similarities and differences were observed when examining the network structures by sex. In both sexes, COVID-19-related stress remained central and was positively associated with fear of COVID-19 and psychological distress. However, notable differences emerged in the strength of associations with males showing

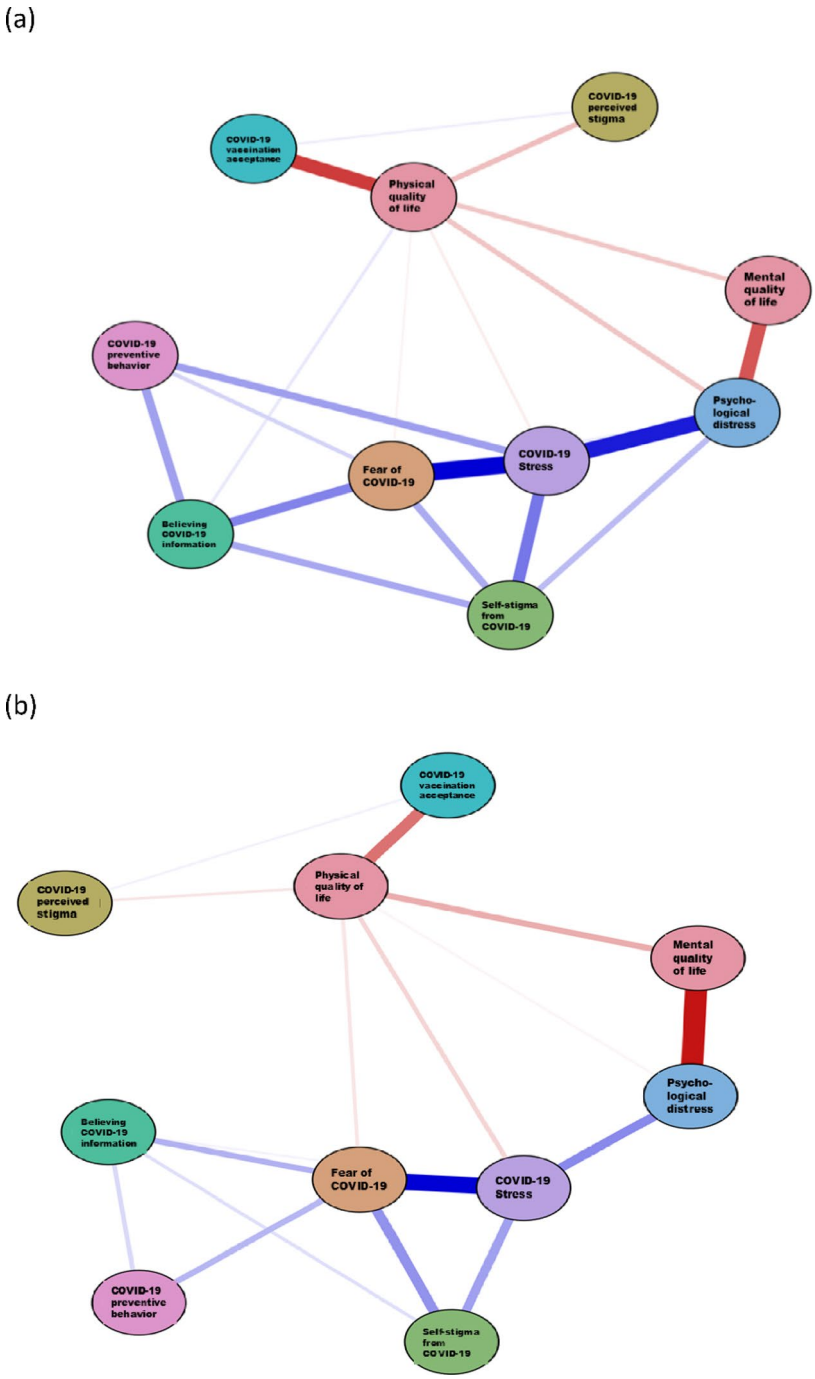

Fig. 3. Network analysis for males and females. **(a).** Male. **(b).** Female.

stronger associations between psychological distress and COVID-19-related self-stigma, and between COVID-19-related stress and COVID-19 prevention behaviors. These sex-based differences aligned with research suggesting that males and females often experience stress differently[48,49]. Studies have shown that males tend to externalize stress through social support or problem-solving strategies, while females might internalize stress, focusing more on emotional regulation[50,51].

Age-based comparisons showed further differences. Participants aged 18 years and older had stronger negative associations between physical quality of life and psychological distress, indicating that older individuals may experience more pronounced physical health problems in response to psychological distress[52]. This may be because they may have greater cognitive or emotional awareness of distress and its impact on their well-being[53]. In contrast, younger participants showed weak associations in these areas, possibly due to several factors. Such factors could include their relative physical resilience or age-related differences in the way psychological distress is perceived, processed, and reported. These findings highlight the importance of considering developmental and cognitive factors when designing age-appropriate mental health interventions.

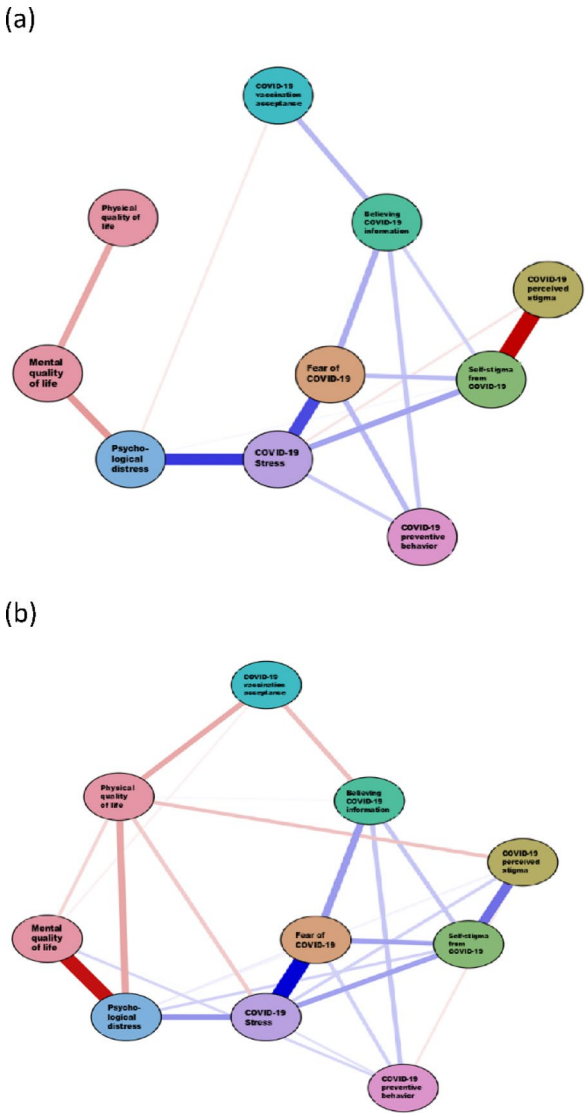

Fig. 4. Network analysis for participants under 18 years and 18 years or older. **(a).** Under 18 years. (**b).**18 years and older.

Educational level appeared to play a considerable role in shaping the network structure. More specifically, university-level participants showed stronger associations between physical quality of life and psychological distress than younger students. This difference may reflect the heightened academic pressures and stress often experienced by older students in higher education. These findings align with prior research, which suggested that educational levels significantly influence stress and pressure experiences[54,55].

Additionally, the relationships between COVID-19-related perceived stigma and COVID-19-related self-stigma, and COVID-19 vaccination acceptance and believing COVID-19 information, varied across education level. These variations suggested that as individuals progress in their education, they may perceive stress differently and have various views on social support and information credibility[56]. University students may develop different coping strategies or rely on diverse social networks. This may influence their perceived support. Similarly, educational attainment could impact attitudes toward COVID-19 vaccine acceptance, potentially due to varying levels of exposure to information sources and health literacy[57,58]. Together, these differences may reflect the influence of education level on both stress perception and attitudes toward public health information.

Limitations and future directions

Although the present study provided insights into the relationships between COVID-19-related variables and health outcomes, there are several limitations that need to be considered. First, the cross-sectional design of the study limited the ability to determine causal relationships. Longitudinal studies are needed to better understand the associations between these factors (e.g., age, sex, and education level) and COVID-19-related outcomes over time in future research. Second, while focusing on Ghanaian students allowed for an in-depth understanding of a specific and important population, the findings may not be fully generalizable to other groups. Future research

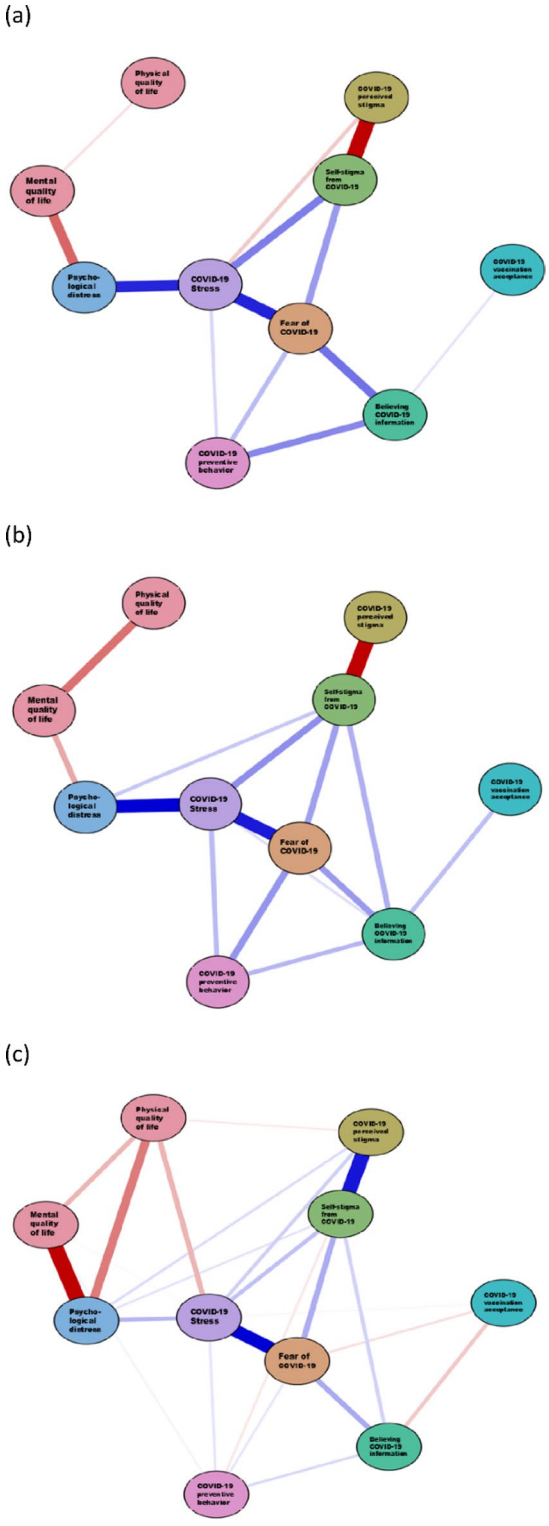

Fig. 5. Network analysis for different education levels. (**a**). Junior high school. (**b**). Senior high school. (**c**). University (undergraduate).

could include more diverse samples, such as individuals from different age groups, religious backgrounds, regions, or occupational settings, to enhance the broader applicability of the results. Third, while network analysis provided a clear understanding of variable associations, it is important to interpret these findings with caution, particularly regarding small associations. Future research should examine the strength of these associations with a broader range of methodological approaches.

Conclusions

The present study highlighted the complex associations between COVID-19-related variables and health across sex, age, and educational levels among adolescents and emerging adults in Ghana. Stress related to the COVID-19 pandemic, rather than stigma, emerged as a key determinant of psychological well-being, while differences in network structures across sex, age, and education level emphasized the need for tailored health interventions. The findings of the present study provide valuable insights into the structural dynamics of these COVID-19-related factors and identify key elements that may support individuals' resilience in coping with the effects of the post-COVID-19 pandemic. Future research should incorporate more diverse samples across regions, age groups, and sociocultural contexts. Longitudinal study designs are especially recommended to track how the relationships among these variables evolve over time.

Data availability

The data supporting the findings of the present study are available from the correspondingauthor upon reasonable request.

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JY: Validation, visualization, writing—original draft, writing—review and editing; IHC: Formal analysis, investigation, validation, visualization, writing—original draft, writing—review and editing; PCH: Formal analysis, investigation, validation, visualization, writing—original draft, writing—review and editing; ESA: Conceptualization, data curation, investigation. Methodology, project administration, supervision, validation, writing—review and editing; FMA: Conceptualization, data curation, investigation, methodology, project administration, supervision, validation, writing—review and editing; IRA: Investigation, methodology, validation, visualization, writing—review and editing; MDG: Investigation, validation, visualization, writing—review and editing; WL: Supervision, validation, visualization, writing—review and editing; DKA: Conceptualization, data curation, investigation, methodology, project administration, validation, visualization, writing—original draft, writing—review and editing; and CYL: Conceptualization, formal analysis, investigation, supervision, validation, visualization, writing—original draft, writing—review and editing. All of the authors have read and agreed to the published version of the manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
The present study was approved by the Committee on Human Research, Publications, and Ethics of the Kwame Nkrumah University of Science and Technology (IRB ref: CHRPE/AP/203/22). All participants provided written informed consent prior to their involvement in the study.

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