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COVID-19 and health information seeking behavior: Digital health literacy survey amongst university students in Pakistan

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Abstract: Amid to the COVID-19 pandemic, digital health literacy (DHL) has become a significant public health concern. This research aims to assess information seeking behavior, as well as the ability to find relevant information and deal with DHL among university students in Pakistan. An online-based cross-sectional survey, using a web-based interviewing technique, was conducted to collect data on DHL. Simple bivariate and multivariate linear regression was performed to assess the association of key characteristics with DHL. The results show a high DHL related to COVID-19 in 54.3% of students. Most of the Pakistani students demonstrated ~50% DHL in all dimensions, except of reliability. Multivariate findings showed that gender, sense of coherence and importance of information were found to be significantly associated with DHL. However, a negative association was observed with students' satisfaction with information. This led to the conclusion that critical operational and navigations skills are essential to achieve COVID-19 DHL and cope with stress, particularly to promote both personal and community health. Focused interventions and strategies should be designed to enhance DHL amongst university students to combat the pandemic.

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1. Introduction

The widespread outbreak of the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV-2) poses a perpetual menace to public health. The World Health Organization (WHO) designated it as novel coronavirus disease 2019 (COVID-19) [1] and constituted this pandemic as a public health emergency of international concern. The COVID-19 pandemic has devastating effects, with more than 100 million confirmed cases and more than 2.3 million deaths across the globe until midst of February 2021 [2]. Currently, Pakistan is the 30th most affected countries across the world and 7th highest hit country in Asia region [3], with more than 560,000 confirmed cases of COVID-19 [4].

The trajectory of daily reported cases in Pakistan revealed a progression of confirmed cases, with steady, high and low dips. A rise in number of reported cases was evident from May 2020 onwards, where the highest peak was observed in June 2020 with more than 6,000 cases in a day, followed by a steadily decrease between July to September 2020 [4]. Later on, the second wave of pandemic erupted and the government of Pakistan announced a second spell of COVID-19 at October 28, 2020, with a gradual increase in daily cases. Most recently, the highest spike of COVID-19 cases was reported on December 6, 2020 with more than 3,700 cases per day [4]. Once again in January, 2021, the number of COVID-19 cases has started to increase, which requires critical attention [4].

With the rapid progression of the COVID-19 pandemic, there is a wake of an 'infodemic', defined as a global epidemic of misinformation and disinformation [5]. Ironically, there is a tsunami of information, grabbing the public's attention in the form of experts' opinions, muffled by a barrage of misguided theories, half-baked pieces of advice, sketchy remedies and rumors on social media platforms and other outlets. Further, the evolving scientific knowledge and research sometimes also raise controversies or reversals in infection prevention recommendations, in a relatively short span of time, crowding out the accurate public health management and making general public more anxious [5,6,7]. For instance, the use of cloth mask (e.g. cotton or gauze) was not recommended initially by WHO, nonetheless, in the light of emerging evidence, the Center for Disease Control and Prevention (CDC) recognized the effectiveness of cloth masks in slowing down the spread of COVID-19 [5].

Since the emergence of the pandemic COVID-19, the disease has become a constant challenge for public health reforms. In the absence of effective treatment and limited availability of vaccination, preventive measures against COVID-19 are critical to control. However, there is a continuous influx of COVID-19 resources at the internet and social media, including both information and misinformation, serving as a double-edged sword [8]. Further, this plethora of complex and discordant information raises even more spread of fear, anxiety, engender confusion, chaos and panic among public than the virus itself [9]. Given the context of the current health dilemma, the issue of health literacy is crucial to tackle the disease, particularly to ensure preparedness of healthcare system and mitigate its effects on individual and societal health.

Health literacy entails knowledge, competence and skills of an individual to attain, process, communicate and comprehend health information and services to promote and improve personal and community health through effective health decisions [10,11,12,13]. Digital Health Literacy (DHL), also phrased as eHealth literacy, is an extension of health literacy within the context of technology or electronic sources of information to understand and address any health problem [14]. Health literacy is a significant empowerment strategy, enabling individuals to seek necessary information, control their own health matters and take responsibility of their actions [15]. In recent years, health literacy has gained significant attention, owing to its association with social determinants of health. The WHO commission on Social Determinants of Health also recognized health literacy in determining health inequalities within low- and middle-income countries [16]. Moreover, the adequacy of health literacy facilitates in improving personal care, creating enabling environment, implementing health policies and achieving health outcomes, particularly in reducing health inequity and stress [15,17]. Nevertheless, low health literacy results into poor self-management and miserable health outcomes [18].

Health literacy is a broader concept, comprising of three domains: functional literacy, interactive literacy, and critical literacy [19]. Functional literacy indicates the task-based knowledge and skills to acquire and act on health information regarding defined risks, recommended use of health services and adherence [12,19]. Interactive literacy describes more advanced cognitive and social skills and competence to extract, comprehend and differentiate between varied sources of health information, through higher level of interaction with experts/professionals [12,19]. Critical health literacy represents the most advanced cognitive and social skills, and competence to critically analyze health information from varied sources and apply this information to exert effective control in both personal and community health [12,19]. Broadly, this classification differentiates the varied literacy skills, which progressively extend from individual health to societal health, enabling autonomy, ensuring active engagement in wider actions and improving health outcomes.

Recognizing the complexity of health systems, health literacy and DHL in particular is known as an emerging field of inquiry, where no one is considered fully health literate and requires necessary support to understand and act upon health information. Specifically, some groups of the population are more prone to low health literacy, such as old age adults, migrants, ethnic or racial minorities, less educated, and people with low socio-

economic and poor health status [20]. Here, the group of young university students (between 17 to 24 years and above) cannot be overlooked, who although are keener to learn new things and enhance DHL skills, however, yet are not fully equipped to critically analyze information and take appropriate decisions for personal and community health. Due to massive misinformation, the infodemic pertaining to COVID-19 highlighted the absence of health literacy proficiency. In turn, it increases stress, anxiety and risks of other morbidities, particularly among young people [12,21,22].

Paascha-Orlow et al. (2005) conducted a systematic review of 85 studies and concluded that 26% people in the United States of America had general low health literacy [23]. Similarly, limited health literacy was found amongst 47% in Europe [24] and 59% in Australia [25]. Though, these statistics depict the situation of developed countries, nonetheless, these also highlight that status of health literacy in developing countries could be more worrisome due to underdeveloped health and education systems. In 2018, a study carried out with adolescents in Pakistan revealed that around 26% of respondents had adequate HL, while 21% had very limited health literacy [26]. In sum, the association of health literacy with increased morbidity and mortality for non-communicable diseases is already evident from previous research [27]. Similarly, the significance of health literacy was equally highlighted for communicable diseases, like the COVID-19 pandemic [28]. Further, COVID-19 also requires individuals and collective readiness and adaptive ability to develop critical health literacy along with prevention and management to ensure compliance.

Overall, there is a paucity of evidence with reference to health literacy and COVID-19 in Pakistan. Given this backdrop, this study was conducted among university students to assess their information seeking behaviors, ability to find relevant information and deal with DHL and the factors associated with DHL in Punjab, Pakistan.

2. Materials and Methods

2.1. Study design and setting

We conducted an online-based cross-sectional study among university students enrolled in any of the Bachelors, Masters, MPhil or doctorate programs in Punjab province, Pakistan. Punjab is the largest province with respect to population size and is comprised of around 53% of the total population of Pakistan. There are 30 general public sector universities in Punjab province. Four universities were selected randomly from the list of 30 general public sector universities. The sample size was calculated on the basis of the size of population (700,000), a fraction of 0.5 and a confidence level of 0.95. For the sample of 1,979 respondents, the level of sampling error was 2.2%.

The survey was conducted by the Department of Public Health, University of the Punjab and Department of Management Sciences, University of Okara as members of COVID-HL research consortium with the technical support of Interdisciplinary Centre for Health Literacy Research at Bielefeld University and Fulda University of Applied Sciences, Germany. The questionnaire developed by them was converted to SurveyMonkey. Few modifications were made in the questionnaire to make it according to the country's educational structure. The link along with an invitation letter for participation to the survey was shared with the heads of different departments in all four universities. These heads then introduce the study and shared the link for participation in the study via email with students in their respective departments. The data collection was continued till the desired sample size was achieved.

The study was conducted as an online-based survey because of the COVID-19 related lockdown in the country at the time of survey. It was conducted from May 1, 2020 to June 15, 2020. Each interview took on average 14 minutes for completion. Total interviews conducted were 1,980. However, 233 incomplete questionnaires were not included in the final analysis.

2.2. Measures

COVID Health Literacy Survey Questionnaire (COVID-HL-Q) was used for data collection [29]. It assesses socio-demographic characteristics such as age (in years), gender (female, male, diverse), and country of birth (Pakistan, another country). Information was also collected regarding students' course of study related variables such as subject group of study (engineering sciences, linguistic and cultural studies, mathematics/natural sciences, medicine/health sciences, law and economics, and social sciences/social work/psychology/education, any other), name of university (University of the Punjab, Okara University, Government College University Faisalabad, and Quaid-e-Azam University), study program (Bachelor, Master, MPhil, PhD, any other), current semester of studies, financing of studies (support by parents, by other family member, employment during the semester or during semester break, scholarship, any other), and satisfaction with financial situation (completely sufficient, sufficient, less sufficient, not sufficient).

Subjective social status of students was measured by using the MacArthur Scale [30]. It is a single item measure that assesses a person's perceived social status with respect to others in his/her group. At the top of the ladder are the people who are the best off having more money and best job. The students were asked to think of a ladder as representing where people in their country stand in and they were asked where they would place themselves on this ladder of a ten-point scale (1-10).

Sense of coherence (SoC) was measured using the 9-item scale developed by Vogt, Jenny and Bauer [31]. The original scale was developed within the work context; however, it was verbally adapted to assess the current living situations of students. The scale measures the three domains of SoC: comprehensibility (manageable, structured, clear, predictable), manageability (easy to influence, controllable), and meaningfulness (meaningful, significant, rewarding). The responses were taken through a 7-point Likert scale (strongly agree to strongly disagree). Cronbach's alpha of the overall scale was 0.89; for the subscales it ranged from 0.87 to 0.89.

Data on HL and information seeking behavior related to COVID-19 was measured by asking question if "the students have searched the internet in the last four weeks for information about the coronavirus". Digital health literacy instrument (DHLI) of Van der Vaart & Drossaert [32] was utilized to assess respondents' skills in information searching, adding self-generated content, evaluating reliability, determining the relevance of COVID-19 related information and protecting privacy. Overall, DHLI comprised of 15 items with 1-4 response options (very easy - very difficult for items 1-12 and never - often for items 13-15). A lower score represents higher level of DHL of students. Cronbach's alpha of the scale was 0.88.

Students were also asked about different sources used for online information searching on a 1-4 response option (never - often), language of the sources used for searching COVID-19 related information (English, Urdu, both Urdu and English) and specific topics used for searching COVID-19 related information. They were also asked about the importance of searched information and their satisfactions with the information found on the internet regarding COVID-19.

2.3. Data analysis

The data was analyzed using Statistical Package for Social Sciences (SPSS) version 26. Univariate analysis was done and descriptive statistics were presented as frequencies, percentages, means, and standard deviations for socio-demographic characteristics, students' studies related variables, and digital health related characteristics. The mean score was used as a cut-off point for SoC and DHL. Bivariate analysis was done using ANOVA and simple linear regression to see the association between socio-demographic characteristics and DHL. Finally, a multiple linear regression was employed to assess the association. Only the variables significant at $P < 0.05$ at bivariate analysis was placed in multivariate analysis. A P -value < 0.05 was considered statistically significant. The Variance Inflation Factor was used to confirm that no multicollinearity between independent variables exists.

2.4. Ethical considerations

The study protocols were reviewed and approved by the Institutional Ethical Review Board at the University of the Punjab (reference No. 132/IERB/PU/2020). Informed written consent was taken before filling out the questionnaires. All respondents were explained about their voluntary participation and ensured about data privacy and anonymity. Before the start of questionnaire, students were explained about the study objectives and its significance. No personal information such as name, phone number and address were collected to ensure the respondents privacy.

3. Results

3.1. Sample characteristics

Table 1 shows that a total of n=1,747 respondents participated in the survey and completed the self-administered questionnaire. The mean age of students was found 22.5 years (SD+4.5). Overall, 52.7% were females and almost all (99.7%) were born in Pakistan. The majority of respondents were studying the courses of mathematics/natural sciences (32.9%), social sciences (23.7%) and engineering sciences (21.3%), under the Bachelor (52.4%), Masters (28.1%) and M.Phil/PhD (19.5%) programs, within the University of Okara (73.4%) and University of the Punjab (19.2%). Regarding students' primary financing sources for studies, more than three fourths of respondents informed that they were supported by their parents (76.8%). Most of the students were found satisfied on having sufficient finances (47.0%), however, few reported about non-sufficient funds (10.9%) at their disposal.

Table 1. Characteristics of respondents (n=1,747).

Characteristics	n ¹	%
Age of respondents	Mean 22.5	SD+4.5
17–20 years	652	37.3
21–24 years	789	45.2
>24 years	306	17.5
Gender		
Male	826	47.3
Female	920	52.7
Study subject groups		
Engineering sciences	371	21.3
Mathematics / Natural sciences	574	32.9
Linguistic and cultural studies	51	2.9
Medicine / Health sciences	68	3.9
Law and economics	111	6.4
Social sciences	422	23.7
Others	150	8.7
University		
University of Okara	1,280	73.4
University of Punjab	336	19.2
Others	131	7.5
Study program		
Bachelor	916	52.4
Master	491	28.1

MPhil/PhD	340	19.5
Semester currently studying		
1–2	759	43.4
3–4	589	33.7
>4	399	22.8
Subjective social status		
Low	364	20.9
Medium	871	49.9
High	508	29.1
Primary source of financing		
Support by parents	1,278	76.8
Student grant	30	1.8
Employment during the semester	211	12.7
Employment during the semester break	5	0.3
Scholarship	39	2.3
Other	101	6.1
Satisfaction with financial situation		
Completely sufficient	244	14.0
Sufficient	817	47.0
Less sufficient	489	28.1
Not sufficient	189	10.9
Overall sense of coherence (SoC)		
High SoC	942	59.8
Low SoC	632	40.2
Comprehensibility		
High	956	59.6
Low	648	40.4
Manageability		
High	1,025	63.5
Low	588	36.5
Meaningfulness		
High	917	56.8
Low	697	43.2

¹ Values do not always sum up to n=1,747 due to missing values.

This research applied the MacArthur Scale of Subjective Social Status to capture the respondents' placement in a social ladder between a score of 1 to 10, indicating top score for best off and bottom for worst off. The mean of MacArthur scale was 5.3 (SD+2.2). The findings revealed that around 21% and 50% respondents belonged to the subjective social status between 1-3 and 4-6 scores in the top ladder for best off. Figure 1 displays the respondents' individual scores on the social ladder.

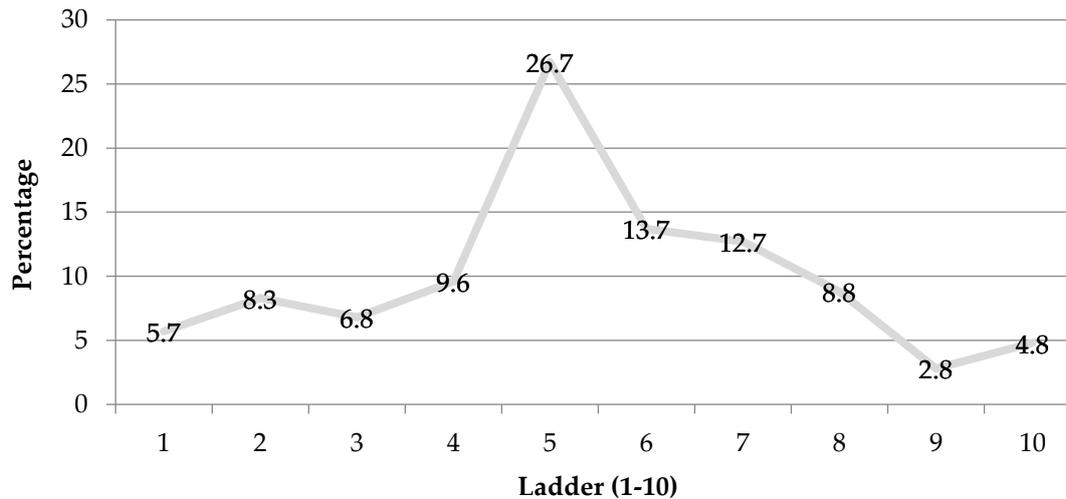


Figure 1. Subjective social status.

3.2. Sense of coherence

Respondents' SoC was determined through assessing their aptitude to apply existing and potential resources to cope with COVID-19 related stress and promote health. Table 1 presents the measurement of SoC, based on students' perception about three broader dimensions, i.e. comprehensibility (cognitive dimension), manageability (behavioral dimension) and meaningfulness (motivational dimension). Findings revealed that a vast majority of students had an overall high level of SoC (59.8%), which is the coping capacity to deal with COVID-19 stress. Similarly, most of the respondents had a high level of comprehensibility (59.6%), manageability (63.5%), and meaningfulness (56.8%) to combat health-related stress.

Furthermore, Table 2 highlights the item-wise results of the three broader dimensions of SoC through psychometric evaluation among study participants against a 7-point Likert scale (strongly agree to strongly disagree) to infer respondents' existing life situations. Results show that a significant number of students were found to (strongly/somewhat) agree towards their current life situations and SoC, which are significant (76.1%), meaningful (75.5%), manageable (74.3%), controllable (71.1%), clear (70.0%), rewarding (69.7%), and structured (69.0%), but to a bit lesser extent easy to influence (67.5%) and predictable (65.4%).

Table 2. Percentage distribution of sense of coherence.

Characteristics	Strongly agree	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	Disagree	Strongly disagree
Manageable (n=1,669)	9.7	36.5	28.1	13.7	5.5	2.8	3.8
Structured (n=1,637)	6.6	36.3	26.1	17.2	6.2	2.7	4.9
Easy to influence (n=1,630)	6.4	35.0	26.1	15.8	7.5	3.4	5.8
Clear (n=1,630)	8.1	40.9	21.0	13.1	7.7	3.3	5.9
Controllable (n=1,622)	8.7	39.8	22.6	13.9	6.2	3.0	5.8
Predictable (n=1,623)	6.7	33.1	25.6	18.1	6.0	3.5	6.9
Meaningful (n=1,627)	12.0	41.4	22.1	12.7	4.4	2.5	5.0
Significant (n=1,628)	11.2	44.0	20.9	11.7	5.3	2.5	4.4
Rewarding (n=1,626)	10.4	36.7	22.6	15.2	5.2	3.3	6.6

3.3. Digital health literacy about COVID-19

Respondents' DHL in relation to COVID-19 was assessed using a number of questions, including purpose, key search areas, sources/means, main topics, frequency and language of searching online information during the four weeks preceding the survey, e.g., number of infected cases and ways to avoid or deal with COVID-19 in daily life. Further, their perception regarding the importance of information and extent of satisfaction was also explored.

Initially, the purpose of searching online information was assessed. Most students reported that they have searched for COVID-19 information on the internet for themselves and other people (55.7%) within four weeks prior to the survey; additionally, 21.4% search information only for themselves and 7.0% only for other people. Only 15.9% of students did not search any information related to COVID-19 on the internet during the previous four weeks.

In order to determine participants' DHL, we used an instrument (DHLI) to measure students' skills for searching COVID-19 related information on the internet, under the following five key dimensions: information searching (DHL search), adding self-generated contents (DHL content), evaluating reliability (DHL reliability), determining relevance (DHL relevance) and protecting privacy (DHL privacy) against a 4-point Likert scale (very easy to very difficult). The findings show that the majority of respondents found the online search for information easy or even very easy, particularly in using the proper words/search query (76.2%), making a choice for information to find (73.2%), and finding the exact information they have been looking for (64.0%). Similarly, most of the respondents claimed that they found DHL content (very) easy regarding adding self-generated content about COVID-19 on various forums or social media platforms (e.g., Facebook or Twitter), including posting messages for people to understand exactly what is meant (67.9%), expressing opinion/thoughts/feeling in writing (63.0%), and clearly formulating question (62.7%). Contrary to the above, a large number of students informed about the difficulty to evaluate the reliability of online information (DHL reliability), in terms of deciding whether the information was reliable (64.5%) or whether the information had commercial interests (53.9%), and verifying the information from different websites (55.9%) (Table 3).

Furthermore, the vast majority of students reported DHL relevancy (very) easy, while deciding about the applicability of the information (68.5%), particularly for healthcare related decision-making (69.9%) and in daily life (68.8%). Lastly, most of the students declared that they never found DHL privacy difficult, while posting messages on a public forum or social media about COVID-19, specifically in judging who can read the posted message (33.5%), sharing their own private (62.5%) or some else' private information (71.7%) (Table 3).

Table 3. Digital health literacy among respondents.

Characteristics	Very easy	Easy	Difficult	Very difficult
Information searching				
Make a choice from all the found information (n=1,470)	24.0	49.2	17.6	9.2
Use the proper words/search query to find information (n=1,452)	18.1	58.1	16.3	7.6
Find the exact information looking for (n=1,450)	16.1	47.9	26	10
Adding self-generated contents				
Clearly formulate question (n=1,451)	12.0	50.7	30.9	6.3
Express opinion, thoughts or feeling in writing (n=1,454)	11.8	51.2	31.6	5.4
Write message as such for people to understand exactly what he/she means (n=1,449)	14.6	53.3	28.6	3.6

Evaluating reliability				
Decide whether the information is reliable or not (n=1,466)	16.3	19.2	41.9	22.6
Decide whether the information is written with commercial interests (n=1,460)	26.6	19.5	32.8	21.1
Check different websites to see whether they provide the same info (n=1,459)	26.5	17.6	36.9	19.0
Determining relevance				
Decide whether the found information is applicable (n=1,447)	13.3	55.2	27.2	4.2
Apply the found information in daily life (n=1,449)	11.3	57.5	28.2	3.0
Use found information to make health-related decisions (n=1,448)	14.3	55.6	26.2	3.9
Protecting privacy				
Find it difficult to judge who can read along the posted message (n=1,458)	33.5	22.3	26.0	18.2
Share private info (n=1,460)	62.5	14.3	15.2	8.0
Share some else' private info (n=1,456)	71.7	12.6	10.6	5.1

Upon computing the items described above, the mean score for the overall DHL was 33.1 (SD+6.1), indicating that on average participants had a high level of DHL to deal with COVID-19 related online-based information. Similarly, the higher mean values for various items of DHL was recorded for DHL reliability (M=7.6, SD+2.3), DHL contents (M=6.8, SD+1.8), DHL relevance (M=6.6, SD+1.7), DHL search (M=6.5, SD+2.1) and DHL privacy (M=5.4, SD+2.1). 54.3% of students had an overall high DHL. Likewise, the vast majority of respondents owned high levels of DHL contents (66.0%), followed by DHL search (57.1%), DHL relevance (55.0%), DHL privacy (53.5%) and DHL reliability (44.4%).

Furthermore, this study explored the frequency of searching online information from various sources/means about COVID-19 (Table 4). Findings revealed that a significant number of young students often sought information through search engines (e.g. Google, Bing, Yahoo; 43.8%), social media (e.g. Facebook, Instagram, Twitter; 39.9%), YouTube (39.7%) and news portals (e.g. newspapers, TV news channels; 36.7%). Nevertheless, respondents sometimes also searched national websites (e.g. National Command Operations Center [NCOC]; 26.5%), Wikipedia and other online-encyclopedias (26.1%), and multiple health blogs (29.4%). Additionally, some of the students informed that they had never searched guidebook communities (35.6%), health portals (31.1%) or doctors/pharmaceutical websites (34.6%).

Table 4. Search for information related to COVID-19 and related topics on the internet.

Characteristics	Often	Sometimes	Rarely	Never	Don't know
Search engines (Google, Bing, Yahoo) (n=1,426)	43.8	31.1	13.3	6.1	5.8
Websites of public bodies (NCOC, provincial health departments) (n=1,415)	22.2	26.5	21.1	19.4	10.8

Wikipedia and other online-encyclopedias (n=1,407)	20.8	26.1	21.3	23.2	8.6
Social media (Facebook, Instagram, Twitter) (n=1,415)	39.9	28.9	12.4	14.0	4.8
YouTube (n=1,414)	39.7	29.9	15.8	11.0	3.5
Blogs on health topics (n=1,399)	18.9	29.4	21.4	23.2	7.0
Guidebook communities (n=1,411)	12.5	20.4	19.8	35.6	11.7
Health portals (n=1,405)	14.2	22.8	20.5	31.1	11.5
Websites of doctors/pharmaceutical companies (n=1,404)	13.7	21.9	18.9	34.6	10.9
News portal (e.g. newspapers, TV stations) (n=1,405)	36.7	34.2	14.5	10.3	4.3

Furthermore, in response to the use of language for seeking online information about COVID-19, the majority of students reported using English language (63.7%). Nonetheless, few respondents either used both English and Urdu languages (19.3%), or Urdu only (17.0%).

Upon exploring the specific search topics for COVID-19 (Table 5), the vast majority of respondents informed that they searched for the current spread of disease/infected cases (57.5%) and symptoms of COVID-19 (15.1%). However, only few students explored the information about transmission routes (5.9%), protective measures (5.2%), economic and social consequences of COVID-19 (3.2%) and others (5.2%).

Table 5. Specific topics searched for in the context of COVID-19 (n=1,470).

Characteristics	n	%
Current spread of COVID-19 (e.g. number of infected cases)	845	57.5
Transmission routes of COVID-19	87	5.9
Symptoms of COVID-19	222	15.1
Individual measures to protect against infection (e.g. hand-washing tips)	76	5.2
Hygiene regulations (e.g. disinfection and cleaning)	23	1.5
Current situation assessments and recommendations	40	2.7
Restrictions (e.g. exit restrictions, stay-at-home orders)	22	1.5
Economic and social consequences of the COVID-19	48	3.2
Dealing with psychological stress caused by COVID-19	31	2.2
Others	76	5.2

The findings presented in Table 6 divulged that most of the students considered the importance of information according to the fact whether they are up-to-date (68.7%), verified (62.6%), or official (62.4%). A relatively high number of respondents prioritized that information which enabled them to quickly learn significant things (56.2%), which are comprehensively (48.4%), and representing different opinions (42.6%).

Table 6. Search for information related to COVID-19 and related topics on the internet.

Characteristics	Very important	Rather important	Rather not important	Not at all important
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The information is up to date (n=1,411)	68.7	22.6	4.5	4.3
The information is verified (n=1,386)	62.6	25.9	6.3	5.3
Quickly learn the most important things (n=1,399)	56.2	31.5	6.5	5.9
The information comes from official sources (n=1,398)	62.4	23.8	7.9	5.9
Different opinions are represented (n=1,391)	42.6	38.2	11.5	7.6
The subject is dealt with comprehensively (n=1,392)	48.4	36.2	8.8	6.6

Lastly, the respondents' extent of satisfaction regarding online information about COVID-19 was inquired against 5-point Likert scale, where the vast majority of students were found either very satisfied (25.6%), satisfied (35.0%), or partially satisfaction (25.2%). Nevertheless, few students were seen dissatisfied (11.2%) or even very dissatisfied (3.0%).

3.4. Relationship between key characteristics and digital health literacy

Table 7 presents the cross-tabulation to explore the relationship between socio-demographic and further characteristics with overall DHL and its five dimensions, i.e. DHL search, DHL content, DHL reliability, DH relevancy and DHL privacy. Overall, a higher mean score of DHL was found among the students between 17–20 years (M=33.45, SD+6.3), females (M=33.57, SD+6.0), studying in the University of Okara (M=33.48, SD+6.3), studying law and economics (M=33.77, SD+5.7), being in a Bachelor program (M=33.19, SD+5.8), suffering from chronic disease (M=33.53, SD+6.5) or any disability (M=33.27, SD+7.1), belonging to relatively low subjective social class (M=33.90, SD+6.6), owing low sense of coherence (M=34.51, SD+6.1), and found somewhat satisfied with information (M=35.08, SD+5.5). A significant relationship of overall DHL ($p < 0.05$) was observed with gender, studying university, subjective social status, sense of coherence, satisfaction and importance of information (Table 7).

Table 7. Relationship between respondent's characteristics and digital health literacy.

Characteristics	Overall DHL (n=1,344)		DHL search (n=1,431)		DHL contents (n=1,435)		DHL reliability (n=1,450)		DHL relevance (n=1,429)		DHL privacy (n=1,451)	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Age of respondents	$P=0.12$		$P<0.001$		$P=0.60$		$P=0.26$		$P=0.12$		$P=0.68$	
17–20 years	484	33.45 (6.3)	511	6.78 (2.1)	521	6.91 (1.8)	527	7.61 (2.2)	522	6.70 (1.7)	532	5.36 (2.0)
21–24 years	619	33.14 (5.9)	664	6.54 (2.1)	655	6.83 (1.7)	664	7.62 (2.3)	651	6.66 (1.7)	661	5.55 (2.1)
>24 years	241	32.42 (6.2)	256	6.11 (2.1)	259	6.60 (1.9)	259	7.89 (2.3)	256	6.44 (1.7)	258	5.45 (2.1)
Gender	$P=0.04$		$P=0.04$		$P=0.005$		$P=0.03$		$P=0.33$		$P=0.68$	
Male	630	32.61(6.2)	670	6.43 (2.1)	674	6.68 (1.8)	679	7.53 (2.2)	671	6.54 (1.7)	683	5.48 (2.0)
Female	714	33.57(6.0)	761	6.66 (2.1)	761	6.95 (1.7)	771	7.78 (2.2)	758	6.72 (1.6)	768	5.44 (2.1)
Study subject groups	$P=0.4$		$P=0.003$		$P=0.21$		$P=0.09$		$P=0.72$		$P=0.32$	
Engineering sciences	275	33.46 (6.8)	291	6.82 (2.3)	297	6.84 (2.1)	296	7.41 (2.2)	297	6.72 (1.9)	298	5.72 (2.1)
Mathematics/ Natural sciences	431	33.23 (5.9)	464	6.67 (2.1)	456	6.94 (1.7)	477	7.61 (2.3)	462	6.66 (1.6)	478	5.37 (2.0)
Linguistic and cultural studies	33	33.75 (7.2)	37	6.89 (2.2)	37	6.86 (1.7)	39	7.48 (2.0)	36	6.72 (1.9)	37	5.45 (2.4)
Medicine/Health sciences	61	33.13 (6.7)	65	6.21 (2.1)	64	6.71 (1.7)	63	7.93 (2.1)	63	6.63 (1.8)	62	5.58 (2.1)

Law and economics	89	33.77 (5.7)	93	6.6 (1.8)	92	7.05 (1.7)	91	8.15 (2.2)	92	6.79 (1.5)	92	5.34 (2.1)
Social sciences	340	32.47 (5.7)	356	6.18 (2.0)	356	6.62 (1.7)	358	7.82 (2.2)	355	6.51 (1.6)	360	5.36 (2.0)
Other	115	33.12 (5.6)	125	6.56 (2.2)	123	6.82 (1.6)	126	7.59 (2.2)	124	6.59 (1.4)	124	5.51 (2.2)
University		<i>P</i> =0.002		<i>P</i> <0.001		<i>P</i> =0.01		<i>P</i> =0.04		<i>P</i> =0.10		<i>P</i> <0.001
University of Okara	965	33.48 (6.3)	1,039	6.75 (2.2)	1,039	6.91 (1.8)	1,061	7.58 (2.3)	1,036	6.74 (1.7)	1,060	5.48 (2.1)
University of the Punjab	273	32.37 (5.6)	284	6.02 (1.8)	288	6.68 (1.7)	283	7.97 (2.2)	285	6.49 (1.5)	283	5.28 (1.9)
Other	106	31.76 (5.4)	108	6.02 (1.8)	108	6.42 (1.9)	106	7.03 (2.0)	108	6.06 (1.6)	108	5.76 (2.1)
Program of studies		<i>P</i> =0.88		<i>P</i> =0.08		<i>P</i> =0.25		<i>P</i> =0.09		<i>P</i> =0.82		<i>P</i> =0.89
Bachelor	705	33.19 (5.8)	744	6.66 (2.1)	745	6.89 (1.7)	750	7.54 (2.2)	745	6.66 (1.7)	757	5.44 (2.0)
Master	378	33.10 (6.4)	403	6.49 (2.1)	410	6.78 (1.8)	416	7.73 (2.3)	409	6.60 (1.7)	412	5.50 (2.1)
MPhil/PhD	261	32.97 (6.3)	284	6.34 (2.1)	280	6.70 (1.8)	284	7.87 (2.4)	275	6.62 (1.7)	282	5.46 (2.1)
Semester currently studying		<i>P</i> =0.33		<i>P</i> =0.40		<i>P</i> =0.80		<i>P</i> =0.07		<i>P</i> =0.32		<i>P</i> =0.79
1–2	587	33.23 (6.5)	623	6.63 (2.2)	627	6.81 (1.8)	635	7.60 (2.2)	624	6.71 (1.7)	634	5.53 (2.1)
3–4	443	33.29 (6.0)	478	6.46 (2.0)	475	6.86 (1.8)	483	7.85 (2.3)	475	6.58 (1.6)	485	5.51 (2.0)
>4	314	32.67 (5.4)	330	6.51 (2.0)	333	6.79 (1.7)	322	7.51 (2.2)	330	6.58 (1.6)	332	5.44 (2.1)
Subjective social status		<i>P</i> =0.01		<i>P</i> <0.001		<i>P</i> <0.001		<i>P</i> =0.07		<i>P</i> <0.001		<i>P</i> =0.14
Low	250	33.90 (6.6)	272	6.97 (2.3)	275	7.04 (1.8)	279	7.39 (2.4)	272	1.84 (1.8)	280	5.5 (2.1)
Medium	667	33.27 (5.7)	719	6.61 (2.0)	711	6.93 (1.7)	722	7.68 (2.1)	711	1.60 (1.6)	723	5.36 (2.0)
High	424	32.48 (6.3)	437	6.21 (2.1)	446	6.53 (1.8)	446	7.78 (2.3)	443	1.67 (1.7)	445	5.61 (2.1)
Primary source of financing		<i>P</i> =0.32		<i>P</i> =0.29		<i>P</i> =0.42		<i>P</i> =0.64		<i>P</i> =0.93		<i>P</i> =0.93
Support by parents	973	33.35 (6.1)	1042	6.61 (2.1)	1,039	6.87 (1.81)	1,048	7.67 (2.3)	1,038	6.66 (1.7)	1,038	6.66 (1.7)
Student grant	24	33.45 (5.6)	25	6.40 (1.6)	26	6.65 (1.7)	26	8.30 (2.5)	26	6.81 (1.7)	26	6.80 (1.7)
Employment during the semester	169	32.50 (5.8)	180	6.31 (1.9)	181	6.70 (1.8)	184	7.72 (2.3)	178	6.60 (1.7)	178	6.60 (1.7)
Employment during the semester break	5	35.20 (5.9)	5	7.40 (2.1)	5	8.20 (2.7)	5	7.60 (2.5)	5	6.60 (2.3)	5	6.60 (2.3)
Scholarship	33	31.78 (5.3)	33	6.09 (1.8)	34	6.64 (1.7)	35	7.25 (2.3)	34	6.44 (1.7)	34	6.44 (1.7)
Other	75	32.82 (7.3)	79	6.37 (2.3)	82	6.84 (1.7)	82	7.52 (2.2)	79	6.54 (1.9)	79	6.54 (1.9)
Sense of coherence		<i>P</i> <0.001		<i>P</i> <0.001		<i>P</i> <0.001		<i>P</i> =0.22		<i>P</i> <0.001		<i>P</i> <0.001
High	773	32.06 (5.8)	811	6.11 (1.9)	818	6.46 (1.7)	823	7.71 (2.3)	814	6.29 (1.6)	814	6.29 (1.6)
Low	508	34.51 (6.1)	548	7.11 (2.2)	537	7.31 (1.8)	546	7.56 (2.2)	537	7.12 (1.7)	537	7.12 (1.7)
Chronic disease		<i>P</i> =0.38		<i>P</i> =0.18		<i>P</i> =0.42		<i>P</i> <0.001		<i>P</i> =0.72		<i>P</i> =0.72
Yes	196	33.53 (6.5)	206	6.73 (2.4)	206	6.92 (1.9)	205	7.19 (2.2)	203	6.60 (1.8)	203	6.60 (1.8)
No	1,095	33.11 (6.0)	1,153	6.52 (2.1)	1,158	6.81 (1.7)	1,177	7.78 (2.3)	1,159	6.65 (1.7)	1,159	6.65 (1.7)
Any disability		<i>P</i> =0.65		<i>P</i> =0.70		<i>P</i> =0.80		<i>P</i> <0.001		<i>P</i> <0.001		<i>P</i> =0.22

Yes	213	33.27 (7.1)	224	6.50 (2.3)	226	6.84 (2.0)	223	7.20 (2.3)	224	5.87 (2.2)	222	6.75 (1.9)
No	1,025	33.06 (5.8)	1,078	6.54 (2.1)	1,077	6.81 (1.7)	1,098	7.74 (2.3)	1,103	5.35 (2.1)	1,080	6.60 (1.6)
Satisfaction with information		<i>P</i> <0.001		<i>P</i> =0.20								
Dissatisfied	171	34.12 (6.8)	182	7.07 (2.4)	186	7.09 (1.9)	189	7.31 (2.3)	182	7.11 (1.9)	189	5.71 (2.2)
Somewhat Satisfied	316	35.08 (5.5)	342	7.11 (2.0)	335	7.20 (1.7)	346	8.11 (2.1)	337	7.11 (1.6)	346	5.40 (2.0)
Satisfied	806	32.22 (5.9)	838	6.21 (2.0)	847	6.63 (1.8)	851	7.61 (2.3)	847	6.35 (1.6)	857	5.43 (2.1)
Importance of information		<i>P</i> <0.001										
Very important	714	32.08 (5.9)	739	6.11 (2.0)	745	6.55 (1.8)	749	7.83 (2.3)	741	6.36 (1.7)	751	5.27 (1.9)
Less important	531	34.69 (5.8)	563	7.10 (2.11)	558	7.22 (1.7)	570	7.59 (2.2)	560	7.01 (1.6)	575	7.59 (2.2)

3.5. Bivariate and multivariate linear regression of key characteristics with digital health literacy

Table 8 illustrates the bivariate and multivariate linear regression of socio-demographics and other characteristics with overall DHL. Simple linear regression was performed to establish the relationship between DHL and key characteristics of respondents. A statistically significant association ($p < 0.05$) was observed with all variables. Furthermore, a multivariate logistic regression analysis was carried out. Results show that students' gender, sense of coherence, satisfaction and appraisal of the importance of information were found to be significantly associated with overall digital health literacy. Multivariate analysis revealed that female students showed 0.93 increase in DHL (95% CI: 0.28–1.56), where a unit increase in sense of coherence was associated with a 0.13 unit increase in their DHL (95% CI: 0.09–0.16). Similarly, a higher likelihood of 2.02 units of DHL was seen among those respondents, who gave importance to information (95% CI: 1.37–2.68). However, a negative association was observed with students' satisfaction with information ($\beta = -1.05$; 95% CI: -1.49–0.59). The R^2 of 0.13 indicated a good model fit.

Table 8. Bivariate and multivariate linear regression of socio-demographic and further characteristics with overall digital health literacy (n=1,344).

Characteristics	Bivariate linear regression			Multivariate linear regression		
	β (SE)	95% CI	P	β (SE)	95% CI	P
Age of respondents	-0.08 (0.04)	-0.15–0.01	0.02	-0.02 (0.04)	-0.09–0.05	0.63
Gender	0.96 (0.33)	0.31–1.62	0.004	0.93 (0.33)	0.28–1.56	0.005
University	-0.94 (0.26)	-1.47–0.42	<0.001	-0.48 (0.27)	-1.01–0.05	0.07
Subjective social status	-0.26 (0.07)	-0.41–0.12	<0.001	-0.09 (0.08)	-0.24–0.06	0.27
Sense of coherence	0.16 (0.16)	0.13–0.19	<0.001	0.13 (0.02)	0.09–0.16	<0.001
Satisfaction with information	-1.4 (0.23)	-1.85–0.94	<0.001	-1.05 (0.23)	-1.49–0.59	<0.001
Importance of information	2.60 (0.34)	1.94–3.26	<0.001	2.02 (0.33)	1.37–2.68	<0.001
Age of respondents	-0.08 (0.04)	-0.15–0.01	0.02	-0.02 (0.04)	-0.09–0.05	0.63

4. Discussion

This study assessed DHL among university students in Pakistan, particularly exploring their information seeking ability and behavior, along with sense of coherence to cope with anxiety. In the time of the COVID-19 pandemic, it is the first kind of cross-sectional study representing the young population in Pakistan and analyzing their DHL – and its associated factors – comprehensively.

Among the socio-demographic characteristics, it is worth mentioning that mostly female students participated in this research. This can be accounted for by course or study program type, with relatively highly feminized fields, covered under this research. The mean score of MacArthur scale of subjective social status was 5.3, highlighting best to moderate positioning of participants within social ladder. It is due to the fact that individuals older than 25 years of age are usually employed, thus are more stable in social ladder [33]. Similar to a Chinese [34] and three Asian countries study [35], this research reported a high level of sense of coherence amongst students – a psychological measure for health promotion to strengthen coping capacity against COVID-19 stress.

4.1. Critical analysis of results in the international context

DHL is a critical and frontline tool to combat the COVID-19 pandemic. Previous research emphasized that people with higher knowledge are more likely to adopt preventive and protective behavior for COVID-19 [36,37]. It is argued that health literacy not only empowers individuals and facilitates in making informed decisions, but also enhances individual capacities for a collective societal response [38].

Along with traditional sources of information such as friends, family and print media, the internet provides a global platform to seek and understand health information for disease control and prevention. Therefore, this research focused on DHL of university students, who are considered frequent users of the internet. The mean score for overall DHL in our study (33.1) is comparable to Norwegian adolescents, where the mean score of 35.2 was reported for health literacy [35]. Further, this research revealed that more than 50% of the university students perceived to have a higher DHL in relation to COVID-19. These findings are comparable with previous studies conducted in Vietnam [17], Europe [24], Germany [40,41] and Midwestern city [42]. However, it is inconsistent with Pakistan [43], France and Spain [44,45], where students had relatively low to moderate levels of health literacy. Findings reiterate that the participants who had higher DHL may have lower risk of COVID-19 infection. Since this research was carried out during the first wave of the COVID-19 pandemic, it could be argued that government policies, preventive measures and public health interventions were observed strictly during lockdown in Pakistan, similar to other countries [40], which may result in higher DHL. Overall, higher DHL is an indicator of individual wellness and self-efficacy for pandemic related stress. These findings support the need for continuous awareness raising for the general population and high-risk communities to enhance DHL and endorse public health [42].

Internet facilitates instant access to the latest information from a variety of sources, allowing control over choices and autonomy to the users. However, it also leads to multiple challenges, including low quality or even unreliable information [46]. Results showed that participants used different means and sources to stay informed during the lockdown. Most of the students searched information about the spread of infected cases and symptoms for themselves and other people. Interestingly, the majority considered the verified and official information most significant to remain informed and showed satisfaction. These findings corroborate to previous similar studies carried out in the context of COVID-19 [39,42,47].

Findings also observed the variance in overall DHL and its five dimensions according to respondents' socio-demographic and educations' acquisition related characteristics (e.g., subject groups, programs and primary financing sources). Here, a proxy measure of subjective social status was used as a potential confounder to determine socio-economic status. The results are consistent with previous research, highlighting that socio-demographic and educational factors affect health literacy outcomes [37,45,49]. This research emphasizes the need to address health literacy deficiencies through improving access and providing continuous education, particularly focusing on rural areas. Further, this research also examined that lack of information influences the students' sense of coherence, which is a protective factor for reducing anxiety. It is evident that the sense of coherence

has the potential to manage available resources and promote mental health during stressful situations, particularly amongst students [34].

DHL requires critical operational and navigations skills for searching online information and applying it in daily lives. Considering the diversity of health information, DHL was categorized into five broader dimensions (search, content, reliability, relevance, and privacy). Our study results show a higher DHL behavior for COVID-19 (~50%) amongst Pakistani students in all dimensions, except for DHL reliability. The dimensions of appraising health information in terms of evaluating reliability and determining relevance are considered more complex competencies, also known as critical HL [49]. Regarding DHL search and content of COVID-19, this research reported that less than one-third of students reported problems to find out the correct information and formulate questions on a relevant topic. However, greatest challenges were observed for assessing the reliability, particularly in judging the information reliability and comparing websites. For DHL relevancy and privacy, some of the students reported difficulties in applying information in daily lives and evaluating the privacy of posted messages. These challenges highlight the interactive character of the internet and social media platforms, which contribute to misinformation, disinformation, and conspiracy theories [50]. Thus, official or public bodies websites are more experts-driven, thus enhance subjective trustworthiness and reliance [46].

This research concludes that health information is accessible from several perspectives and sources, ranging from personal social media posts to scientific data and experts' opinions including government officials, media spoke persons, researchers and academicians to ensure quality health of communities. Along with the progression of pandemic, health literacy has become a serious concern due to the influx of information, which may raise problem in findings and applying appropriate information. Although the internet provides the opportunity to verify statistics, deliver high quality evidence and consult technical experts, nonetheless, inaccurate and misleading information may also result into risky or harmful behavior in the worst cases.

4.2. Limitations

The study has some limitations. Within the cross-sectional design, we only captured findings related to the first wave of the COVID-19 pandemic. Since COVID-19 is a highly demanding field with rapid changes, it covers only the status of DHL at a specific point in time. Because of the online-based assessment, we could not include proportionate samples from each university. One might expect that particularly those students participated in the study who are familiar with the internet due to the online-based study conduction. This might lead to a bias in results, although the age-group in general and students in particular are overall familiar with the internet. Another limitation refers to the fact that all information is self-reported. This limitation is particularly relevant for social status and DHL. In addition, one needs to keep in mind that DHL as not been assessed by using an instrument testing the functional health literacy. However, the study is based on a tool that has been validated in the international context.

5. Conclusions

The research provides an insight into university students' DHL, their approach to seek health information and behavior related to COVID-19 for promoting both personal and community health. This research also provides an insight in lieu of the COVID-19 crisis, requiring immediate attention of government, communities and individuals to adopt protective behavior and cope with complex health situations. Firstly, the government should invest more in health education and initiate focused interventions of health promotion and preparedness in response to the prevailing situation. Secondly, structural and interdisciplinary approaches should be adopted to engage communities and media through awareness raising and health education programs to enhance DHL in view of the

infodemic. Thirdly, universities should expand digital learning opportunities to improve DHL and reinforce digital skills and competences amongst students of Pakistan.

Since students are the agents of information, this research calls for a program to promote DHL, particularly involving students from rural areas and high-risk communities. It is envisaged that evidence of this research would be beneficial for policy makers, health educators and public health practitioners, engaged in health literacy programs for informed decision making as well as to improve and enhance DHL. Health literacy requires individual and system preparedness to resolve complex real-life issues. Amid the pandemic and infodemic, COVID-19 related health literacy is an underestimated problem – a key indicator to acquire necessary health information and adopt protective behavior.

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