

# Post-Traumatic Effects of COVID-19 and its Trans Generational Epigenetics

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**Abstract:-** Specific responses and environmental factors trigger a cascade of genetic alternations which pass on to future generations. The Coronavirus disease 2019 (COVID-19), the pandemic has created a huge disaster and environmental effect around the globe which can cause an enormous change in the forthcoming generation. This study is aimed to assess the post-traumatic effects of this pandemic on Pakistan's residents. Hence, we have investigated the distressing effects of COVID-19 on Pakistan's general population through an online survey to envisage the upcoming belongings. Over 1.1k respondents recorded their responses. The data reflect the impact of the COVID-19 outbreak on change in physical and mental health, financial conditions, anxiety/depression, and immunity, which can revolutionize the new generation's dynamics.

**Keywords:-** Physical and mental health; financial conditions; anxiety/depression; immunity; COVID-19; epigenetics

## I. INTRODUCTION

Since covid-19 has spread to over 213 countries around the world [1, 2] with 595,445,417 confirmed cases, including 6,455,188 deaths, as of August 15, 2022 (<https://www.worldometers.info/coronavirus/>), the World Health Organization (WHO) has declared COVID-19 the sixth public health emergency of international concern [3] and a global pandemic [4]. In such circumstances, individuals may experience suicidal ideation, psychosis, trauma, and panic during outbreaks of contagious diseases [5-7]. Moreover, severe economic conditions in the developing countries, overestimation by the infected person, concerns about the future, the facility of health and medical needs to control the disease, and doubts about the competence of measures; can all be the motives that may cause anxiety/depression [8-13]. Furthermore, severe outcomes of a pandemic include changes in physical and mental health [14-16], financial conditions [17], and the approach to deal with the disease that elevates depression. Nervousness, when above its normal level, weakens the immune system and increases the risk of viral infection [5]. The intensity of its influence and the time duration which is not counted in days or months but years has intensified anxiety to a dangerous level. So, directly or indirectly, people's traumatic experiences will be transferred to the next generation. Environmental effects and lifestyle factors have an impact on genes and their reproductive outcomes [18]. The environmental factors and specific responses initiate a cascade of genetic alternations that pass

on to upcoming generations. These environmental aspects may include, the sensitivity to spreading diseases, stress response, severe changes in financial, mental and physical conditions, anxiety and depression which may suppress the immune system in human beings that eventually have effects on the succeeding generations. Furthermore, lack of emotional support and a traumatic environment around the mother writes the startup page for the epigenetic story of the offspring in a negative way. The environmental belongings in early development have a role in receptiveness to disease in future life which appears to pass through succeeding generations [19]. Many scientists followed generations after a certain disaster such as the Vietnam War and World War II [20]. Follow-up study regarding anxiety symptoms on birth during pandemic has already been reported [21]. Past studies on epigenetics reflect that maternal mental health can change the gene expression in toddlers leading to later life health problems [22]. Epigenetics comprises the means by which environmental factors can change gene expression without changing the genetic sequence [23, 24]. The transgenerational epigenetics effect includes the determination of phenotypes that are not influenced by any gene code, instead, they are influenced by human activity, and their exposure to a specific environment [22, 25, 26], duration of that exposure, and response towards it which affects gene expression in upcoming generations [27]. The time of that exposure is also a considerable aspect. To some extent, it is specific at which age, exposure to what type of stress will affect an organism in what way. Trans generational effects will last for generations so their impact should be studied before time to deal with them. In 2022, the need of the hour is to keep tracing the victims of this recent pandemic COVID-19.

## II. METHODOLOGY

### A. Design and Sampling

An online 15-questions survey form was applied to collect the data, comprising on 3 sections; one with socio demographic information of the respondent (gender, age, marital status, qualification, study status, job/business, and province), the second part consists on COVID-19's impact on physical and mental health, financial conditions, anxiety/depression, and immunity, and the last section comprehending COVID-19 pandemic-related general information (corona-related news, follow-up, etc.). The Snowball sampling strategy [28] was adopted as it is the best way for online surveys using electronic media for areas that are far from dwellings [29, 30]. None of the questions was mandatory and respondents had to respond

autonomously, consequently, each question had a slightly different comeback.

Variables	Items	Frequency	Percentage	Valid Percent
<b>Gender</b>	Male	631	55.7	56.5
	Female	486	42.9	43.5
	Total	1117	98.6	100.0
	Missing	16	1.4	
Total		1133	100.0	
<b>Age category</b>	11-20 Years	184	16.2	16.2
	21-30 Years	323	28.5	28.5
	31-40 Years	324	28.6	28.6
	41-50 Years	216	19.1	19.1
	> 50 Years	78	6.9	6.9
	Total	1133	100.0	100.0
<b>Marital Status</b>	Single	512	45.2	45.6
	Married	551	48.6	49.1
	Divorced	41	3.6	3.7
	Widowed	18	1.6	1.6
	Total	1122	99.0	100.0
	Missing	11	1.0	
Total		1133	100.0	
<b>Qualification status</b>	Under Matriculation	27	2.4	2.4
	Matriculation	40	3.5	3.6
	Intermediate	291	25.7	25.9
	Graduation	561	49.5	49.9
	Post-Graduation	205	18.1	18.2
	Total	1124	99.2	100.0
	Missing	9	0.8	
Total		1133	100.0	
<b>Student status</b>	No	683	60.3	61.0
	Yes	437	38.6	39.0
	Total	1120	98.9	100.0
	Missing	13	1.1	
Total		1133	100.0	
<b>Job/Business status</b>	No	381	33.6	33.9
	Yes	742	65.5	66.1
	Total	1123	99.1	100.0
	Missing	10	0.9	
Total		1133	100.0	
<b>Living Provence</b>	Punjab	496	43.8	44.5
	Sindh	258	22.8	23.1
	KPK	225	19.9	20.2
	Balochistan	136	12.0	12.2
	Total	1115	98.4	100.0
	Missing	18	1.6	
Total		1133	100.0	

Table 1: Frequency distribution of respondents according to sociodemographic variables

**B. Data Collection Tools**

Sociodemographic information was collected about; gender, age, marital status, qualification, study status, residential location (province), and job status. The survey form was disseminated to higher secondary level schools, colleges, universities, and private institutions through social media sources such as Instagram, WhatsApp, Twitter, Facebook, etc., and they were encouraged to pass it on to their recognized groups. Sampling was readily available and it served as the most convenient form of a survey as the

internet boom is seen over the past decade in Pakistan [31]. The introductory paragraph of the survey form with a full description of the purpose of the study was stated and participants’ consent to contribute to the study was obtained. The survey form was available online to collect data from May 14 and it took 3 weeks (14 May to 5 June) to finish.

C. Data Analysis Technique

After the data was gathered, it was exported to SPSS version-23 software for descriptive statistics (frequency distribution, mean and standard deviation) and inferential statistical analyses (correlation, T-test).

III. RESULTS

The respondents were independent to respond due to no constraint on the questionnaire or any question. Consequently, out of 1133 respondents, only 1125 individuals submitted their filled questionnaire.

Variables	Items	Frequency	Percent	Valid Percent
<b>COVID-19 patient status</b>	not a COVID patient	718	63.4	64.1
	COVID patient	402	35.5	35.9
	Total	1120	98.9	100.0
	Missing	13	1.1	
	Total	1133	100.0	
<b>The main source of COVID information</b>	from others	24	2.1	2.1
	newspapers	60	5.3	5.3
	Family/friends	62	5.5	5.5
	news websites	232	20.5	20.6
	T. V	328	28.9	29.2
	social media	418	36.9	37.2
	Total	1124	99.2	100.0
	Missing	9	0.8	
Total	1133	100.0		
<b>Follow up on Corona-related news</b>	never followed	63	5.6	5.6
	always followed	163	14.4	14.5
	occasionally followed	171	15.1	15.2
	sometime follow	250	22.1	22.3
	often followed	476	42.0	42.4
	Total	1123	99.1	100.0
	Missing	10	0.9	
Total	1133	100.0		

Table 2: Corona-related information from respondents

There is also a slight variation in each question's response due to no restriction. The average response time was 1678 s (almost 28 minutes), for 99.3% of respondents. Most of the respondents 496 (44.5%) are from Punjab; the largest populated province [32] followed by 258 (23.1%) from Sindh, 225 (20.2%) from KPK, and, 136 (12.2%) from Balochistan. Response from males was 56.5 % while the rest was from females which is very decent. Divorced (3.7 %) and 1.6 % widowed also responded to our questionnaire. As for the concern of age maximum response was from 21-40 years (57.5%) which is our main focus. Teenagers' response was 16.4% along with 6.9 % of those above 50 years old. Nearly 66 % of our respondents are doing a job/business and the rest of them, are jobless or in student life. As far as student status is concerned, 39 % are currently students while the rest of the respondents have completed their education. Explicitly, 75.8 % of graduates and undergrads responded to this research, whereas, more than 18 % of post-grad were also a part of this response, while the remaining were matric pass or under matric. Complete sociodemographic information is in **Table 1**. Pakistan had adopted a smart lockdown [33, 34] and due to the strong immunity of the people of Pakistan, the outbreak has not had as swear impact as in European countries. The findings

reflect that almost 64 % didn't get COVID-19 and the rest were affected by it. Only 5.6 % of people never followed the COVID-19-related news whereas, almost 57 % of the respondents always/often were in touch with the news. The rest of the population knew about it, from time to time. The source of information for Pakistanis is 37.2 % from social media, 29.2% from television (TV), and other sources are depicted in **Table 2**.

**Table 3**, represents the statistical data regarding, Change in Physical Health (CPH), Change in Mental Health (CMH), and Change in Financial Conditions (CFC) during and after the COVID-19 pandemic along with the Development in Anxiety/Depression (DAD) due to COVID-19 and Trust in Immunity to Recover from Disease (TIRD).The findings from Table 03 show that only 2 % of people claim to have a positive effect on their physical health and 36.4 % of the population think that there was no effect on their physical health during this COVID pandemic. The rest of the people (51.5 %) think that this pandemic has negatively affected their physical health (32.2 % slightly negative and 29.3 % extremely negative). As for the concern of mental health; only 4 % of the people have positive effect and 27.5% has responded that COVID-

19 has no effect on them. Nearly 34 % of respondents indicate that COVID-19 has an extremely negative effect on their mental health whereas, 34.4 % claim that this pandemic caused a change in their mental health slightly negatively. Almost 46 % of people pointed out that their financial conditions were affected extremely negatively whereas, 31.5 % are of the view that this COVID pandemic has a slightly negative effect on their financial conditions. Here, 42 % of people claim to develop moderate anxiety/depression during this pandemic, and nearly 33 % of

the population think that a little bit of depression was developed during this COVID-19 outbreak. Only 7.7 % of the population considered anxiety as severe, and almost 17.5 % are of the view that there is no question of DAD in this pandemic. Furthermore, in Pakistan’s population, 49.5 % of people moderately trust in their immunity to recover from disease, and 22.4 % of them have a firm belief that they can recover due to their immunity. Only 5.3 % don’t trust their immunity to recover and the rest of the population has a little bit of trust in their immunity.

Variables	Items	Frequency	Percent	Valid Percent
<b>CPH due to COVID-19</b>	positive effect	23	2.0	2.1
	no effect	407	35.9	36.4
	slightly negative effect	360	31.8	32.2
	extremely negative effect	328	28.9	29.3
	Total	1118	98.7	100.0
Missing	System	15	1.3	
Total		1133	100.0	
<b>CMH due to COVID-19</b>	positive effect	45	4.0	4.0
	no effect	308	27.2	27.5
	slightly negative effect	386	34.1	34.4
	extremely negative effect	382	33.7	34.1
	Total	1121	98.9	100.0
Missing	System	12	1.1	
Total		1133	100.0	
<b>CFC during COVID-19 pandemic</b>	positive effect	39	3.4	3.5
	no effect	212	18.7	18.9
	slightly negative effect	353	31.2	31.5
	extremely negative effect	517	45.6	46.1
	Total	1121	98.9	100.0
Missing	System	12	1.1	
Total		1133	100.0	
<b>DAD due to COVID pandemic</b>	not at all	196	17.3	17.5
	a little bit	369	32.6	32.9
	moderate	472	41.7	42.0
	severe	86	7.6	7.7
	Total	1123	99.1	100.0
Missing	System	10	0.9	
Total		1133	100.0	
<b>TIRD</b>	not at all	59	5.2	5.3
	a little bit	256	22.6	22.9
	moderately	554	48.9	49.5
	extremely	251	22.2	22.4
	Total	1120	98.9	100.0
Missing	System	13	1.1	
Total		1133	100.0	

Table 3: Frequency distribution of effects of COVID-19 on the general population of Pakistan

The illative results from SPSS statistics are shown in **Table 4**. Correlation between CPH, CMH, CFC, and DAD was estimated for both genders to examine their consequences on TIRD. This shows that the correlation of both the genders with CPH ( $r = 0.164, p < 0.01$ ), CMH ( $r = 0.167, p < 0.01$ ) and DAD ( $r = 0.204, p < 0.01$ ) is positive, moderate and significant. That means females felt more negative effects on their CMH, CPH, and DAD due to the COVID-19 pandemic than males. On the other hand, the CFC ( $r = -0.008, p > 0.01$ ) and TIRD ( $r = -0.056, p > 0.01$ ) have negative, weak, and insignificant relation and, lower in females as compared to males, i.e., females felt slightly less

CFC and have less confidence in TIRD. Our data reflects that CPH ( $r = 0.164, p < 0.01$ ) has positive, moderate and significant relation with CMH ( $r = 0.724, p < 0.01$ ), CFC ( $r = 0.552, p < 0.01$ ) and DAD ( $r = 0.511, p < 0.01$ ) whereas, it has negative, weak and insignificant relation with TIRD ( $r = -0.028, p > 0.01$ ). Moreover, CMH ( $r = 0.724, p < 0.01$ ) has positive, stronger and significant relation with DAD ( $r = 0.561, p < 0.01$ ) and weak, negative and significant relation with TIRD ( $r = -0.090, p < 0.01$ ). Thus, CMH has stronger relations with DAD and TIRD as compared to CPH. Consequently, we conclude that a slight variation in CMH

during the pandemic has caused more DAD and enormous reduction in TIRD as compared to CPH.

An independent samples t-test was conducted to compare DAD due to the COVID-19 pandemic for males and females as shown in **Table 5**. This test reflects that there were significant differences ( $t(df) = 1111, p = 0.000$ ) in the scores with mean score for Male ( $M = 1.662, SD = 1.32$ ) was lower than Female ( $M = 2.206, SD = 1.26$ ). The magnitude of the differences in the means (mean difference =  $-0.54, 95\% CI: -0.70$  to  $-0.39$ ) was significant. Hence there is a significant difference in DAD due to COVID-19 in males and females. Furthermore, our t-test to compare TIRD for both genders reflects that there were no significant differences ( $t(df) = 1093, p = 0.059$ ) in scores for Males ( $M = 1.933, SD = 0.85$ ) and Females ( $M = 1.843, SD = 0.74$ ). The magnitude of the differences in the means (mean difference =  $0.09, 95\% CI: -0.00$  to  $0.18$ ) was very small. Hence, there is no significant difference between the two genders for TIRD.

**IV. DISCUSSION**

Although females’ response is less than males, yet very reasonable. Most of the respondents lie in the range of 21-40 years of age and, the married reply is slightly large than singles. More than three fourth of replies fall in the graduate and post-graduate category, and the majority is doing job or business. All four provinces responded to our survey; therefore, it is presumed that a reasonable count was recorded from all over Pakistan. The majority responding to our survey didn’t get COVID-19 but they often follow corona-related news from social media (TV, websites). It is found that access to the internet and social media caused increasing confusion and great hype including fear of morbidity and mortality of the disease [35]. The hype created on social media, the fake scenarios, and everything related to it, left a mark on the minds of people. No matter how hard someone tries to forget them, the memories will keep on haunting them. This indicates that it was so important to educate the people during the covid times on how to respond and decrease the upcoming influence of the pandemic but due to lack of awareness, it was not possible.

Our inferential statics show that CPH has changed CMH and CFC sturdily, consequently, DAD is increased and TIRD decreased. Moreover, females developed more anxiety/depression during the pandemic than males and there isa significant difference in DAD between the two genders.

Variable	Gender	CPH due to COVID-19	CMH due to COVID-19	CFC during COVID-19 pandemic	DAD due to COVID pandemic	TIRD	
<b>Gender</b>	Pearson Correlation	1	0.164**	0.167**	-0.008	0.204**	-0.056
	Sig. (2-tailed)		0.000	0.000	0.787	0.000	0.064
	N	1117	1108	1111	1111	1113	1109
<b>CPH due to COVID-19</b>	Pearson Correlation	0.164**	1	0.724**	0.552**	0.511**	-0.028
	Sig. (2-tailed)	0.000		0.000	0.000	0.000	0.349
	N	1108	1118	1117	1116	1117	1115
<b>CMH due to COVID-19</b>	Pearson Correlation	0.167**	0.724**	1	0.582**	0.561**	-0.090**
	Sig. (2-tailed)	0.000	0.000		0.000	0.000	0.003
	N	1111	1117	1121	1119	1120	1117
<b>CFC during COVID-19 pandemic</b>	Pearson Correlation	-0.008	0.552**	0.582**	1	0.416**	-0.052
	Sig. (2-tailed)	0.787	0.000	0.000		0.000	0.080
	N	1111	1116	1119	1121	1120	1116
<b>DAD due to COVID-19 pandemic</b>	Pearson Correlation	0.204**	0.511**	0.561**	0.416**	1	0.097**
	Sig. (2-tailed)	0.000	0.000	0.000	0.000		0.001
	N	1113	1117	1120	1120	1123	1118
<b>TIRD</b>	Pearson Correlation	-0.056	-0.028	-0.090**	-0.052	0.097**	1
	Sig. (2-tailed)	0.064	0.349	0.003	0.080	0.001	
	N	1109	1115	1117	1116	1118	1120

Table 4: Correlations between the factors affecting gender during and after the COVID-19 Pandemic  
 \*\*. Correlation is significant at the 0.01 level (2-tailed)



Levene's Test  
for Equality  
of Variances t-test for Equality of Means

		Mean	SD	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
											Lower	Upper
<b>DAD</b>	Male	1.662	1.3137									
	Female	2.206	1.2612	3.913	0.048	-6.959	1111	0.000	-0.5439	0.0782	-0.6972	0.3905
<b>TIRD</b>	Male	1.933	0.8534									
	Female	1.843	0.7373	9.794	0.002	1.887	1093	0.059	0.0903	0.0478	-0.0036	0.1814

Table 5: Independent Samples Test

Furthermore, females trust less in their immunity to recover from disease than males, and there is no significant difference in TIRD between the two genders. We conducted a survey that surveys the TIRD, CPH, CMH, CFC, and DAD during and after the COVID-19 pandemic of the common people of Pakistan. Our research specifically deals with the area of environmental epigenetics and possible changes caused by COVID-19 which can enhance anxiety/depression and decrease immunity to recover from disease consequently, influencing the offspring. We attempt to find the vulnerable post-traumatic COVID pandemic outcomes that have changed the expected scenario.

## V. CONCLUSION

The research findings show that females trust less in their immunity to recover from disease as compared to males and developed more anxiety/depression during this pandemic. Moreover, females face more financial curtailment and had a more negative effect on mental health during COVID-19 as compared to males. From this research, it is also concluded that the most important thing is to trace the stress response elevation in humans not only in Pakistan but also in other parts of the world and mark the possible dangers accordingly. This needs to emphasize the fact that the upbringing by mothers of post-COVID times will have a negative impact on the infants. Every citizen, especially females, needs to be educated in this regard. At the individual level, behavioral changes are in need to be adopted. People need to control their overthinking and overstressing and stop implicating fake news with real conditions so that their stress responses will lower eventually. Moreover, in developing countries especially where financial issues are always on top, local community, government and Non-Government Organizations (NGOs) should step in to overcome such crises. The government of Pakistan initiated Ehsaas Emergency Cash Program (EECP) to cope with financial crises and overcome poverty [36]. Such programs should be introduced to the locality to overcome anxiety, depression, etc., after epidemics or pandemics such as the COVID-19 outbreak which will cut short the chances of trans generational epigenetic stress transfer to future generations.

Natural disasters such as epidemics, pandemics, famine, droughts, floods, volcanic eruptions, and earthquakes act as a natural experiment. Such experiments cannot be organized in laboratories because of a common reason; human rights. So, by nature, this pandemic made it possible to test the transgenerational epigenetic effect. Teams keep the record of the generation affected by the remote disaster and then the next generation is studied afterward based on records kept about the previously affected generation [37, 38]. Similarly, in the case of COVID-19, environmental effects on the general population can be kept in record to investigate its influence on the offsprings. This survey provides a basis for it and our intention is to deal with such issues in the future.

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## REFERENCES

- [1.] Junejo, Y., et al., *Novel SARS-CoV-2/COVID-19: Origin, pathogenesis, genes and genetic variations, immune responses and phylogenetic analysis*. Gene Reports, 2020. 20: p. 100752.
- [2.] Lone, S.A. and A. Ahmad, *COVID-19 pandemic—an African perspective*. Emerging microbes & infections, 2020. 9(1): p. 1300-1308.
- [3.] Moghanibashi-Mansourieh, A., *Assessing the anxiety level of Iranian general population during COVID-19 outbreak*. Asian Journal of Psychiatry, 2020. 51: p. 102076.
- [4.] Djalante, R., et al., *Review and analysis of current responses to COVID-19 in Indonesia: Period of January to March 2020*. Progress in Disaster Science, 2020. 6: p. 100091.

- [5.] Organization, W.H., *Mental health and psychosocial considerations during the COVID-19 outbreak, 18 March 2020*. 2020, World Health Organization.
- [6.] Taylor, M.R., et al., *Factors influencing psychological distress during a disease epidemic: Data from Australia's first outbreak of equine influenza*. BMC Public Health, 2008. 8(1): p. 347.
- [7.] Tucci, V., et al., *The forgotten plague: Psychiatric manifestations of ebola, zika, and emerging infectious diseases*. Journal of Global Infectious Diseases, 2017. 9(4): p. 151-156.
- [8.] Salari, N., et al., *Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis*. Globalization and health, 2020. 16(1): p. 1-11.
- [9.] Mazza, M.G., et al., *Anxiety and depression in COVID-19 survivors: Role of inflammatory and clinical predictors*. Brain, behavior, and immunity, 2020. 89: p. 594-600.
- [10.] Özdin, S. and Ş. Bayrak Özdin, *Levels and predictors of anxiety, depression and health anxiety during COVID-19 pandemic in Turkish society: The importance of gender*. International Journal of Social Psychiatry, 2020. 66(5): p. 504-511.
- [11.] Sher, L., *The impact of the COVID-19 pandemic on suicide rates*. QJM: An International Journal of Medicine, 2020. 113(10): p. 707-712.
- [12.] Sher, L., *COVID-19, anxiety, sleep disturbances and suicide*. Sleep medicine, 2020. 70: p. 124.
- [13.] Banerjee, D., *The COVID-19 outbreak: Crucial role the psychiatrists can play*. Asian Journal of Psychiatry, 2020. 50: p. 102014.
- [14.] Moreno, C., et al., *How mental health care should change as a consequence of the COVID-19 pandemic*. The Lancet Psychiatry, 2020. 7(9): p. 813-824.
- [15.] Talevi, D., et al., *Mental health outcomes of the CoViD-19 pandemic*. Rivista di psichiatria, 2020. 55(3): p. 137-144.
- [16.] Pierce, M., et al., *Mental health before and during the COVID-19 pandemic: a longitudinal probability sample survey of the UK population*. The Lancet Psychiatry, 2020. 7(10): p. 883-892.
- [17.] Douglas, M., et al., *Mitigating the wider health effects of covid-19 pandemic response*. Bmj, 2020. 369.
- [18.] Nayan, V., S.K. Onteru, and D. Singh, *Reproduction and nutriment–nurture crosstalk: epigenetic perspectives*. Journal of Reproductive Health and Medicine, 2015. 1(2): p. 50-59.
- [19.] Jirtle, R.L. and M.K. Skinner, *Environmental epigenomics and disease susceptibility*. Nature Reviews Genetics, 2007. 8(4): p. 253-262.
- [20.] Francis, R.C., *Epigenetics: The Ultimate Mystery of Inheritance*. First ed. 2011, London: W. W. Norton & Company.
- [21.] Nolvi, S., et al., *Parental depressive and anxiety symptoms as a response to the COVID-19 pandemic: a birth cohort follow-up study*. 2020.
- [22.] Gitau, R., et al., *Maternal micronutrient status and decreased growth of Zambian infants born during and after the maize price increases resulting from the southern African drought of 2001–2002*. Public Health Nutrition, 2007. 8(7): p. 837-843.
- [23.] Handel, A.E., G.C. Ebers, and S.V. Ramagopalan, *Epigenetics: molecular mechanisms and implications for disease*. Trends in Molecular Medicine, 2010. 16(1): p. 7-16.
- [24.] Mazzio, E.A. and K.F. Soliman, *Basic concepts of epigenetics: impact of environmental signals on gene expression*. Epigenetics, 2012. 7(2): p. 119-130.
- [25.] Harville, E.W., X. Xiong, and P. Buekens, *Hurricane Katrina and Perinatal Health*. Birth, 2009. 36(4): p. 325-331.
- [26.] Tan, C.E., et al., *The Impact of the Wenchuan Earthquake on Birth Outcomes*. PLOS ONE, 2009. 4(12): p. e8200.
- [27.] Skinner, M.K. and C. Guerrero-Bosagna, *Environmental signals and transgenerational epigenetics*. Epigenomics, 2009. 1(1): p. 111-117.
- [28.] Ali, A., M. Ahmed, and N. Hassan, *Socioeconomic impact of COVID-19 pandemic: Evidence from rural mountain community in Pakistan*. Journal of Public Affairs, 2021. 21(4): p. e2355.
- [29.] Leighton, K., et al., *Using Social Media and Snowball Sampling as an Alternative Recruitment Strategy for Research*. Clinical Simulation in Nursing, 2021. 55: p. 37-42.
- [30.] Browne, K., *Snowball sampling: using social networks to research non-heterosexual women*. International Journal of Social Research Methodology, 2005. 8(1): p. 47-60.
- [31.] Khan, N., et al., *Influence of mobile phone and internet technology on income of rural farmers: Evidence from Khyber Pakhtunkhwa Province, Pakistan*. Technology in Society, 2022. 68: p. 101866.
- [32.] Tahir, S.N.A., et al., *Measurements of activity concentrations of naturally occurring radionuclides in soil samples from Punjab province of Pakistan and assessment of radiological hazards*. Radiation Protection Dosimetry, 2005. 113(4): p. 421-427.
- [33.] Farooq, F., J. Khan, and M.U.G. Khan, *Effect of Lockdown on the spread of COVID-19 in Pakistan*. arXiv preprint arXiv:2005.09422, 2020.
- [34.] Khan, S.D., L. Alarabi, and S. Basalamah, *Toward Smart Lockdown: A Novel Approach for COVID-19 Hotspots Prediction Using a Deep Hybrid Neural Network*. Computers, 2020. 9(4): p. 99.
- [35.] Manzoor, I., *Pakistan and the COVID-19 challenges*. Journal of Fatima Jinnah Medical University, 2020. 14(1): p. 1-2.
- [36.] Jafree, S.R. and N. Anwar, *Social Protection for Socioeconomically Vulnerable Women of Pakistan-During Covid-19 and Beyond*. 2020.
- [37.] Smith, C.A., *The effect of wartime starvation in Holland upon pregnancy and its product*. American Journal of Obstetrics and Gynecology, 1947. 53: p. 599-606.
- [38.] Painter, R., et al., *Transgenerational effects of prenatal exposure to the Dutch famine on neonatal adiposity and health in later life*. BJOG: An International Journal of Obstetrics & Gynaecology, 2008. 115(10): p. 1243-1249.