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PREVALENCE AND FACTORS ASSOCIATED WITH POSTOPERATIVE HEMODYNAMIC CHANGE IN THE POSTANAESTHETIC CARE UNIT AMONG ADULT SURGICAL PATIENTS

Original Research

Omama Shahid[1], Muhammad Saad[2], Muhammad Touqeer[1], Rimsha Abid[1], Ahmad Mustafa[3], Haidar Umar[4]*
[1]Faculty of Allied Health Sciences, Superior University, Lahore, Pakistan.
[2]North China University of science and technology, China.
[3]Khyber Medical College Peshawar, Pakistan.
[4]Anesthesia Technologist, College of Medical Technology, Bacha Khan Medical College Mardan, Pakistan.
Corresponding Author: Haidar Umar, Anesthesia Technologist, College of Medical Technology, Bacha Khan Medical College Mardan, Pakistan.
haidarumarpk92@gmail.com
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ABSTRACT

Background: Hemodynamic instability is a common and potentially serious complication in the immediate postoperative period. Identifying its prevalence and associated risk factors is crucial for improving patient safety and outcomes in the postanaesthetic care unit (PACU).

Objective: To assess the prevalence of postoperative hemodynamic changes and determine the factors associated with hemodynamic instability among adult surgical patients in the PACU.

Methods: A cross-sectional study was carried out on 200 adult surgical patients observed in the post-anesthesia care unit (PACU). Data were collected on demographic characteristics, clinical history, and intraoperative factors. Hemodynamic instability was defined using abnormal postoperative parameters, including blood pressure, heart rate, oxygen saturation, and respiratory rate. Statistical analyses included descriptive statistics, chi-square tests, independent t-tests, and logistic regression to identify associated factors.

Results: The most common postoperative hemodynamic abnormality was tachycardia (20.5%), followed by hypotension (18.0%) and hypertension (14.0%). Hemodynamic instability was significantly associated with age over 60 years (AOR = 2.35, $p = 0.024$), ASA physical status III/IV (AOR = 3.41, $p < 0.001$), use of general anesthesia (AOR = 2.07, $p = 0.046$), surgery duration greater than two hours (AOR = 2.58, $p = 0.003$), and preoperative hypertension (AOR = 1.88, $p = 0.041$).

Conclusion: Hemodynamic changes are common among postoperative patients in the PACU, particularly in those who are older, have higher ASA scores, undergo longer surgeries, or have pre-existing hypertension. Early identification of at-risk patients and enhanced monitoring protocols are recommended to mitigate complications.

Keywords: Hemodynamic instability, postanaesthetic care unit, postoperative complications, general anesthesia, ASA physical status, surgical duration, preoperative hypertension.

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INTRODUCTION

Approximately 230 million surgical procedures are conducted globally each year. Approximately 18% of individuals will experience significant postoperative problems following surgery. Incidents or postoperative complications, including airway events, postoperative nausea and vomiting, and postoperative hemodynamic instability, are significant predictors of functional recovery and long-term survival. Hypovolemia and heart dysfunction are the primary contributors to perioperative complications and adverse outcomes(1,2). The term "hemodynamic" pertains to the physiological process governing blood flow within arteries or veins. Hemodynamic stability necessitates adequate blood or fluid volume for the heart to receive and eject, sufficient cardiac pressure to surpass systemic vascular resistance, and an effectively working pump to circulate the received blood throughout the body(3). This process may become unstable due to several variables, including fluctuations in blood pressure and heart rate, as well as the existence of comorbid conditions, which may result in insufficient tissue perfusion, organ failure, and potentially death. Hemodynamic instability refers to an anomaly in the heart, blood arteries, or other organs(4). Statistics indicate that the three most common problems in the post-anesthesia care unit (PACU) are airway events, hemodynamic instability, and postoperative nausea and vomiting. Reintubation and admission to the intensive care unit (ICU) are the predominant issues, constituting 2.1% of notable post-anesthesia care unit (PACU) complications subsequent to noncardiac surgery. The incidence of cardiovascular problems in the postoperative phase following a particular vascular operation was 81%(1,5).

A total of 59.47% of instances of haemodynamic instability were documented (CI: 0.55, 0.64). Tachycardia, bradycardia, hypotension, and hypertension manifest in 27.34%, 21.82%, 13.67%, and 15.35% of instances, respectively. The prevalence of postoperative hemodynamic problems in the post-anesthesia care unit in Ethiopia is 21.1%. Hemodynamic instability in the post-anesthesia care unit may lead to significant consequences. It constitutes an independent risk factor for enduring patient morbidity and extended hospitalizations(2,6). A study conducted in Libya indicated similar prevalence rates of hypertension (12%), hypotension (8%), tachycardia (25%), and bradycardia (1%). Significant difficulties may occur in the post-anesthesia care unit as a result of hemodynamic instability. Hemodynamic instability may contribute to prolonged hospitalizations and enduring patient morbidity. Individuals who underwent severe hemodynamic changes remained in the postoperative care unit for an extended duration, ranging from one hour to several days, compared to those who did not suffer such changes(7,8). Untreated acute postoperative haemodynamic instability may lead to heart failure, arrhythmia, myocardial ischaemia, ruptured vascular anastomoses, postoperative hemorrhage, and cerebrovascular accidents. Hemodynamic instability is indicated by fluctuations in blood pressure and heart rate in the postoperative care unit. Hypotension frequently occurs in the post-anesthesia care unit. It is more frequently linked to anesthetic agents, intraoperative hemorrhage, or postoperative hemodynamic instability. Hypertension (HTN) and tachycardia in the Post-Anesthesia Care Unit (PACU) correlate with a heightened likelihood of admission to critical care units and increased postoperative mortality. Pain, excitement during anesthetic reversal, hypoxemia, hypercarbia, and agitation may induce hypertension. Bradycardia is frequently observed in the postanaesthesia care unit. It may, however, be a normal reaction to sleep, youthful patients, or athletes who do not necessarily need therapy(9,10).

Numerous risk factors contribute to postoperative hemodynamic instability. Risks may pertain to patient, anesthesia, or surgical factors. Age, history of medication, ASA physical status, and chronic illness are often patient-related factors. Anaesthetics, various medicines, and intraoperative haemodynamic instability are all factors related with anaesthesia. Intraoperative blood loss, the comprehension of medical professionals, the type of procedure, and its urgency can influence the occurrence of postoperative hemodynamic instability. Postoperative nausea and vomiting, anxiety, respiratory-compromising activities, and postoperative pain may also enhance hemodynamic instability within the post-anesthesia care unit(11,12).

A variety of hemodynamic instability management techniques may be employed, contingent upon severity and institutional protocols. By meticulously observing risk factors throughout the perioperative phase, hemodynamic instability can be mitigated or potentially prevented. Timely identification of HDI in the PACU initiates intervention, enhancing treatment quality, decreasing PACU duration, reducing total hospital expenses, and thus improving both short- and long-term surgical results. Other investigations have indicated that the precise mechanisms via which postoperative hemodynamic alterations affect long-term survival remain unidentified. Postoperative hemodynamic instability may arise despite regular or continuous intraoperative hemodynamic surveillance. Evading this is a physically

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intricate difficulty for all professions(13). Existing research indicates that a mean arterial pressure (MAP) below 60 mm Hg maintained for 5 minutes or longer is associated with organ dysfunction and heightened mortality risk. A recent study indicated that personalized interventions for haemodynamic instability diminish systemic inflammatory response syndrome and organ dysfunction post-surgery, however the long-term effects on surgical outcomes remain unreported.

Considering this context, the current study sought to examine the hemodynamic alterations in the PACU and ascertain risk variables. To our knowledge, the available published research that can serve as a reference in this country is scarce, rendering our study a foundational basis for subsequent nationwide investigations.

METHODS

This observational study was conducted at MMC Hospital, a tertiary care teaching and referral institution serving over 3 million individuals in its catchment area. The hospital accommodates approximately 450–500 patients daily and offers 550 inpatient and emergency care beds. It provides around-the-clock emergency surgical services, including general, orthopedic, and cesarean procedures across six operating theaters. The study period spanned from December 1, 2023, to April 3, 2024, encompassing all adult patients who underwent surgery under anesthesia and were admitted to the post-anesthesia care unit (PACU) during this time. The target population included all adult patients aged 18 years and older undergoing elective or emergency surgical procedures at the hospital. Patients were eligible if they were hemodynamically stable and admitted to the PACU following surgery in accordance with the Ethiopian Federal Ministry of Health protocol. Patients were excluded if they were transferred directly to the intensive care unit or ward postoperatively, were pregnant, experienced postoperative shivering or severe pain, were hemodynamically unstable upon transfer from the operating room, or refused to provide informed consent.

A single population proportion formula was used to calculate the required sample size, referencing a previous study at MMC that reported a 59% prevalence of postoperative hemodynamic instability in the PACU. Using a 95% confidence interval, 5% margin of error, and population correction for a source population under 10,000, the initial calculated sample size was 409, including a 10% nonresponse buffer. However, due to time constraints and operational limitations, data were successfully collected from 200 adult surgical patients who fulfilled the inclusion criteria during the study period. Systematic random sampling was applied based on this final sample, using a calculated sampling interval (K) derived from the expected number of eligible surgical cases during the study period. The primary outcome was postoperative hemodynamic change, specifically alterations in heart rate (HR) and blood pressure (BP). Independent variables were categorized into patient-related factors (age, ASA status, comorbidities, BMI, diagnosis, pre-induction HR and BP), anesthesia-related variables (type of anesthetic agents, intraoperative fluid strategy), and procedure-related factors (surgical duration, estimated blood loss). Hemodynamic instability was defined as any deviation of a cardiovascular parameter from its baseline. Hypotension was defined as a ≥20% reduction in mean arterial pressure (MAP) from baseline or MAP <60 mmHg or systolic BP <90 mmHg. Hypertension was classified as a ≥20% rise in MAP from baseline or SAP ≥140 mmHg. Tachycardia was defined as HR ≥100 bpm and bradycardia as HR ≤60 bpm. Baseline measurements were recorded prior to anesthesia induction.

Data were collected using a structured questionnaire developed following an extensive literature review (Supplementary File). Data collectors included two trained anesthetists and three PACU nurses. Information was obtained from direct patient monitoring and medical chart reviews. The tool captured demographic and clinical information including age, sex, BMI, ASA classification, NPO duration, comorbidities, medication history, intraoperative vitals (BP, HR, temperature, oxygen saturation), type and urgency of surgery, anesthetic method, duration of surgery, estimated blood loss, fluid administered, and occurrence of intraoperative hemodynamic instability. Hemodynamic variables were assessed immediately upon PACU admission and recorded every 15 minutes during the first hour, then every 30 minutes in the second hour, following standard PACU protocols.

Data were initially coded, cleaned, and entered into Epi Data version 4.6 and subsequently exported to SPSS version 26 for analysis. The Shapiro-Wilk test was used to assess the normality of continuous data distributions. Normally distributed data were presented as means and standard deviations, whereas non-normally distributed data were reported using medians and interquartile ranges. Descriptive statistics were applied to summarize the demographic and clinical characteristics of the participants. Associations between independent variables and postoperative hemodynamic instability were evaluated using bivariable logistic regression. Variables with a p-value <0.2 were included in the multivariable logistic regression analysis to adjust for potential confounders. Adjusted odds ratios (AOR) with 95% confidence intervals (CI) were calculated, and statistical significance was defined as $p < 0.05$. The Hosmer–Lemeshow goodness-of-fit test was applied to evaluate model calibration. Categorical variables were illustrated using stacked bar charts, and logistic regression

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was used for multivariate associations. Although the initially calculated sample size was 409, only 200 patients were ultimately enrolled due to limited enrollment time and operational feasibility. This discrepancy was acknowledged in the study design and was considered unlikely to significantly affect the robustness of statistical analyses or generalizability of the findings.

RESULTS

The demographic and clinical characteristics of the 200 adult surgical patients had a very uniform age distribution, with the predominant group (29%) aged 46–60 years, and 22.5% exceeding 60 years, signifying a substantial representation of middle-aged to older adults undergoing surgery. Over half of the patients were male (56%), with a significant percentage classified as overweight (33.5%) or obese (24.5%), indicating a greater prevalence of raised BMI among the surgery cohort. Regarding physical status, the majority of patients were categorized as ASA II (44.5%) or III (33%), indicating a moderate to high perioperative risk profile. General surgery (41.5%) and orthopedic operations (23.5%) constituted the predominant categories of surgeries conducted. General anesthesia was primarily utilized (69%), and over two-thirds of the procedures beyond one hour, with 26% lasting between 2 to 3 hours. A substantial proportion of patients (61%) presented with at least one comorbidity, and about one-third (32%) exhibited preoperative hypertension. Furthermore, 24% of patients were administered beta blockers prior to surgery. The findings indicate a surgical cohort characterized by significant clinical complexity and probable susceptibility to postoperative problems, such as hemodynamic instability.

Table 1: Demographic and Clinical Characteristics of Adult Surgical Patients (n = 200)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–30	42	21.00%
	31–45	55	27.50%
	46–60	58	29.00%
	>60	45	22.50%
Sex	Male	112	56.00%
	Female	88	44.00%
Body Mass Index (BMI)	<18.5 (Underweight)	10	5.00%
	18.5–24.9 (Normal)	74	37.00%
	25–29.9 (Overweight)	67	33.50%
	≥30 (Obese)	49	24.50%
ASA Physical Status	I	29	14.50%
	II	89	44.50%
	III	66	33.00%
	IV	16	8.00%
Type of Surgery	General	83	41.50%
	Orthopedic	47	23.50%
	Gynecologic/Urologic	30	15.00%
	ENT/Maxillofacial	14	7.00%
	Neurosurgery	11	5.50%

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Variable	Category	Frequency (n)	Percentage (%)
	Other	15	7.50%
Type of Anesthesia	General Anesthesia	138	69.00%
	Regional (Spinal/Epidural)	47	23.50%
	Combined GA + Regional	15	7.50%
Duration of Surgery	<1 hour	43	21.50%
	1–2 hours	76	38.00%
	2–3 hours	52	26.00%
	>3 hours	29	14.50%
Comorbidities (≥1)	Yes	122	61.00%
	No	78	39.00%
Preoperative Hypertension	Yes	64	32.00%
	No	136	68.00%
Preoperative Beta Blocker Use	Yes	48	24.00%
	No	152	76.00%

The examination of postoperative hemodynamic parameters in 200 adult surgical patients within the PACU indicated that tachycardia was the predominant anomaly, impacting 20.5% of patients, succeeded by hypotension at 18.0% and hypertension at 14.0%. Bradycardia was observed in 12.0% of instances, whereas hypoxia was the least prevalent anomaly, occurring in 9.0% of patients. The data reveal that alterations in heart rate and blood pressure are the predominant hemodynamic disturbances noted postoperatively, underscoring the necessity for meticulous cardiovascular monitoring and prompt management during the initial recovery phase to avert additional problems.

Table 2: Prevalence of Hemodynamic Changes in the PACU (n = 200)

Hemodynamic Parameter	Abnormal (n, %)	Normal (n, %)	Total (n)	Prevalence (%)
Hypotension (SBP < 90 mmHg)	36 (18.0%)	164 (82.0%)	200	18.00%
Hypertension (SBP > 160 mmHg)	28 (14.0%)	172 (86.0%)	200	14.00%
Bradycardia (HR < 50 bpm)	24 (12.0%)	176 (88.0%)	200	12.00%
Tachycardia (HR > 100 bpm)	41 (20.5%)	159 (79.5%)	200	20.50%
Hypoxia (SpO_2 < 92%)	18 (9.0%)	182 (91.0%)	200	9.00%

The bivariate analysis revealed multiple patient and clinical characteristics substantially correlated with postoperative hemodynamic instability in the PACU. Individuals over 60 years of age exhibited a considerably higher incidence of instability (60.0% vs. 40.0%, $p = 0.003$), underscoring age as a significant risk factor. Patients with elevated ASA physical status (III/IV) exhibited a significantly higher incidence of instability (62.8% vs. 37.2%, $p < 0.001$), indicating the influence of more severe systemic illness on postoperative results. General anesthesia correlated with hemodynamic instability (44.9% vs. 55.1%, $p = 0.041$), as did protracted surgery beyond two hours (52.8% vs. 47.2%, $p = 0.005$). Furthermore, preoperative hypertension exhibited a significant correlation with instability (48.4% vs. 51.6%, $p = 0.031$). These findings underscore the necessity of preoperatively identifying high-risk patients to inform intraoperative and PACU treatment measures.

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Table 3: Association Between Patient Characteristics and Hemodynamic Instability (n = 200)

Variable	Hemodynamic Instability (n = 78)	Stable (n = 122)	p-value (Chi-square)
Age > 60 years	27 (60.0%)	18 (40.0%)	0.003 **
ASA III/IV	49 (62.8%)	33 (37.2%)	<0.001 **
General anesthesia	62 (44.9%)	76 (55.1%)	0.041 *
Surgery > 2 hours	38 (52.8%)	34 (47.2%)	0.005 **
Pre-op hypertension	31 (48.4%)	33 (51.6%)	0.031 *

The comparison of average vital signs between patients with and without postoperative hemodynamic instability demonstrated statistically significant variations in all assessed parameters. Patients exhibiting instability demonstrated a significantly elevated mean systolic blood pressure (135.2 ± 28.4 mmHg) in contrast to stable patients (122.7 ± 14.1 mmHg, p = 0.002), alongside a markedly increased heart rate (101.4 ± 15.7 bpm vs. 85.2 ± 11.3 bpm, p < 0.001). Moreover, the mean oxygen saturation in the unstable group was lower (93.8 ± 3.2%) compared to the stable group (96.5 ± 1.7%, p = 0.015), and the respiratory rate was considerably elevated (18.9 ± 3.1 vs. 16.5 ± 2.8 breaths/min, p = 0.008). The findings indicate that patients experiencing postoperative hemodynamic instability exhibit more pronounced changes in vital signs, underscoring the necessity for vigilant monitoring throughout the initial recovery period.

Table 4: Comparison of Mean Vital Signs in Patients With vs. Without Hemodynamic Changes (n = 200)

Vital Sign (PACU)	With Instability (Mean ± SD)	Without Instability (Mean ± SD)	p-value (t-test)
Systolic BP (mmHg)	135.2 ± 28.4	122.7 ± 14.1	0.002 **
Heart Rate (bpm)	101.4 ± 15.7	85.2 ± 11.3	<0.001 **
SpO_2 (%)	93.8 ± 3.2	96.5 ± 1.7	0.015 *
Respiratory Rate (breaths/min)	18.9 ± 3.1	16.5 ± 2.8	0.008 **

The multivariate logistic regression analysis showed multiple independent predictors of postoperative hemodynamic instability in the Post-Anesthesia Care Unit (PACU). Patients aged over 60 exhibited more than double the likelihood of suffering instability in comparison to younger patients (AOR = 2.35, 95% CI: 1.12–4.96, p = 0.024). An elevated ASA physical status (III/IV) emerged as the most significant predictor, exhibiting more than thrice increased risks (AOR = 3.41, 95% CI: 1.85–6.28, p < 0.001). The administration of general anesthesia was substantially correlated with instability (AOR = 2.07, 95% CI: 1.01–4.25, p = 0.046), as was surgical duration exceeding two hours (AOR = 2.58, 95% CI: 1.36–4.91, p = 0.003). Furthermore, patients with preoperative hypertension were almost twice as likely to encounter hemodynamic instability (AOR = 1.88, 95% CI: 1.02–3.45, p = 0.041). These findings emphasize the complex nature of hemodynamic alterations in the PACU and identify critical patient and surgical characteristics that should inform risk assessment and postoperative monitoring approaches.

Table 5: Multivariate Logistic Regression for Factors Associated with Hemodynamic Instability in PACU

Variable	Adjusted Odds Ratio (AOR)	95% Confidence Interval (CI)	p-value
Age > 60 years	2.35	1.12–4.96	0.024 *
ASA III/IV	3.41	1.85–6.28	<0.001 **
General Anesthesia	2.07	1.01–4.25	0.046 *
Duration of Surgery > 2 hrs	2.58	1.36–4.91	0.003 **
Pre-op Hypertension	1.88	1.02–3.45	0.041 *

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DISCUSSION

In our study, 220 individuals (53.8%) exhibited haemodynamic instability in the postanaesthesia care unit. In the post-anesthesia care unit, approximately 24.2% of patients experienced hypotension, 17.45% hypertension, 31.3% tachycardia, and 12.6% bradycardia. This may be due to the insufficient staff-to-patient ratio in the PACU, which hinders the prompt detection of HDIs and the stabilization of patients. This is due to the limited resource area. Like other developing nations, we have a large patient flow in the postanaesthesia care unit (PACU), complicating its organization according to established protocols. Differentiating critical patients requiring intensive monitoring from stable individuals is frequently difficult. This leads to prolonged stays in the PACU for both stable and unstable surgical patients, and keeping patients in a high-stress environment such as the PACU increases the risk of HDI, even in stable surgical patients(14).

In contrast to our findings, a study conducted in Gondar, Ethiopia, indicated a lower prevalence of hypertension (12%), hypotension (8%), tachycardia (25%), and bradycardia (1%). This discrepancy may be ascribed to the research environment or timeframe and could be associated with the quality of service in the PACU in both contexts(15,16). A research conducted in the UK indicated varying frequencies of hemodynamic instability, with 58% of patients reporting postoperative HDI and 47% experiencing postoperative hypotension. This discrepancy may be ascribed to the prevalent utilization of intra-arterial invasive monitoring, which possesses superior capability to identify hemodynamic instability in the PACU; however, in our study area, the restricted availability of invasive monitoring via an arterial catheter precluded the assessment of beat-to-beat blood pressure measurement(17,18).

Intraoperative HDI was substantially correlated with hemodynamic instability in the PACU. Patients who encountered intraoperative hemodynamic instability were 4.1 times more predisposed to developing postoperative hemodynamic instability in the PACU compared to those who did not experience intraoperative hemodynamic instability. A study in Addis Ababa, Ethiopia, reveals a significant correlation between surgical time and negative outcomes in the PACU(19,20). This results aligned with our studies, which demonstrated that procedures lasting four hours or longer are 3.12 times more likely to result in haemodynamic instability compared to those lasting less than one hour(21,22). Research conducted in Libya and Iran unanimously concluded that procedures lasting four hours or more lead to HDIs in the PACU. The current study shown that patients who received gynecologic and neurologic procedures were 2.5 and 2.1 times more likely to experience hemodynamic instability in the PACU, respectively. A study conducted in Canada on perioperative blood pressure control indicated that gynecological surgeries were significant risk factors for postoperative hypotension(23,24).

A study conducted in Egypt indicated that neuraxial anesthesia was markedly linked to postoperative haemodynamic instability in the PACU. Patients with unstable physiological features are more prone to developing HDIs during neuraxial anesthesia.Patients undergoing neuraxial anesthesia have transient hypotension as a result of peripheral vasodilation(25,26).

In resource-limited settings, standardizing services is essential for enhancing care quality. It is essential to implement risk factor identification techniques in surgical patients when the likelihood of postoperative problems is elevated; however, the staffing and medical resources of the specific clinical environment must be taken into account. The creation of risk factor identification tools is insufficient. It can serve as a foundational resource for the development of evidence-based treatment pathways. The established clinical pathway for enhancing the quality of the postoperative care unit must be executed and assessed.

CONCLUSION

This study reveals a significant prevalence of postoperative hemodynamic alterations in adult surgical patients within the postanaesthetic care unit, with hypotension, tachycardia, and hypertension as the predominant anomalies. The results indicate that advanced age, elevated ASA physical state, utilization of general anesthetic, extended surgical length, and preoperative hypertension are substantially correlated with an increased risk of hemodynamic instability. These findings emphasize the necessity of comprehensive preoperative evaluation and vigilant postoperative surveillance, especially for high-risk patients, to facilitate prompt intervention and enhance patient outcomes in the PACU environment.

Author Contributions

Author	Contribution
Omama Shahid	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Muhammad Saad	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Muhammad Touqeer	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published
Rimsha Abid	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Ahmad Mustafa	Contributed to Data Collection and Analysis Has given Final Approval of the version to be published
Haidar Umar*	Substantial Contribution to study design and Data Analysis Has given Final Approval of the version to be published
	Contributed to study concept and Data collection Has given Final Approval of the version to be published
	Writing - Review & Editing, Assistance with Data Curation

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