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# The change of clinical features and surgical outcomes in patients with pressure injury during the COVID-19 pandemic

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## Abstract

This retrospective study aims to explore whether the COVID-19 pandemic altered patient conditions and surgery outcomes by studying 213 pressure injury (PI) patients who underwent surgery during 2016 to 2019 (pre-COVID) and 2020 to 2021 (COVID) in Taiwan. We extracted patient demographics, surgical and blood test records, preoperative vital signs, and flap surgery outcomes. In total, 464 surgeries were performed, including 308 pre-COVID and 156 COVID. During the COVID period, there were more patients presenting with dementia, and it had significantly more patients with >12 000 white blood cells/μL (24.03% vs 15.59%, $P = 0.029$), higher C-reactive protein levels (7.13 ± 6.36 vs 5.58 ± 5.09 mg/dL, $P = 0.014$), pulse rates (86.67 ± 14.76 vs 81.26 ± 13.66 beats/min, $P < 0.001$), and respiratory rates (17.87 ± 1.98 vs 17.31 ± 2.39 breaths/min, $P = 0.009$) but lower haemoglobin levels (9.75 ± 2.02 vs 10.43 ± 1.67 mg/dL, $P < 0.001$) preoperatively. There were no between-group differences in flap surgery outcomes but had fewer flap surgeries during COVID-19. Thus, PI patient condition was generally poor during the COVID-19 pandemic because of reduced

Ching-Ya Huang and Chiung-Wen Chang contributed equally to this study.

access to medical treatment; this problem may be resolved through holistic care during a future pandemic or pandemic-like situation.

KEYWORDS
COVID-19, holistic management, pressure injury

**Key Messages**

- the pandemic of COVID-19 has significantly delayed the treatment and influenced the prognosis of disease, especially for patients with pressure injury (PI) who requires a long-term individualised plan
- insufficient haemoglobin, poor infection control, and unstable vital signs were noted in a patient with PI during the COVID-19 pandemic, because of reduced access to medical treatment
- the uncorrected medical problems delayed the appropriate timing for patients with PI to undergo flap surgery. Thus, thorough early management and correction of patient conditions is an urgent need during the COVID-19 pandemic
- holistic care may be the most appropriate management strategy for improving the prognosis of patients with conditions such as PIs during a pandemic-like period

## 1 | INTRODUCTION

The COVID-19 pandemic has considerably and negatively affected numerous lives and economies worldwide; specifically, it has led to delays in seeking medical treatment among many people.[1-3] Delaying or avoiding seeking medical advice can result in worsened symptoms, delayed evaluation, and treatment complications.[4-7] Moreover, the pandemic has significantly impacted health care systems, leading to numerous issues including shortages of medical staff, beds, equipment, medicines, and isolation facilities. The concern of cross-contamination—where COVID-19 may spread within wards unknowingly—has also increased the emotional burden among health care workers.[8-10]

Pressure injury (PI) is a common health issue, particularly among older people who have physical limitations or are bedridden. PI management often requires a long-term individualised plan. Failure to implement this strategy may influence the quality of life and may cause wound-related psychosocial issues (eg, low self-esteem), increase health care expenditures, and shorten survival among the patients.[11] Moreover, long-term PIs are prone to infection and bleeding, which may lead to sepsis or anaemia.[12-14]

The current study explored whether COVID-19 pandemic-related changes affected the characteristics and treatment outcomes of patients with PIs.

## 2 | METHODS

### 2.1 | Patients and data extraction

We reviewed the electronic medical records of all patients who received debridement or flap-reconstruction surgery for PIs at Wan Fang Hospital from January 2016 to December 2021. This study was approved by the hospital's institutional review board. The work has been reported in line with the STROCSS criteria.[15] Official study registry: https://www.clinicaltrials.gov/ (NCT05409170).

Each surgical procedure was considered an independent event. Moreover, the January 2016 to December 2019 and January 2020 to December 2021 intervals were defined as pre-COVID and COVID periods, respectively. Patients who underwent debridement or flap-reconstruction surgery across the pre-COVID and COVID periods were excluded from the study.

We collected patient demographic data including age, sex, body mass index (BMI), smoking status, disease status (for diabetes mellitus, coronary artery disease, hypertension, Parkinson's disease, dementia, and haemodialysis), and follow-up duration (from first surgery date to the latest hospital record). Surgical records including PI locations and stage [according to the National Pressure Ulcer Advisory Panel (NPUAP) staging system],[16] ostectomy status, drainage tube retention period (in days) [including use of Jackson–Pratt drain, Hemovac, negative pressure wound therapy (NPWT), and Penrose drain], and hospital stay

length (in days) were extracted, as were blood test data including white blood cell count (WBC), actual neutrophil count (ANC), actual lymphocyte count (ALC), haemoglobin (Hgb), serum creatinine level, estimated glomerular filtration rate (eGFR), albumin (Alb) level, platelet count, C-reactive protein (CRP) level, and glycated Hgb A1c content (HbA1c). Finally, we collected data regarding the vital signs on the day before surgery, including body temperature (BT), pulse rate (PR), respiratory rate (RR), systolic blood pressure (SBP), and diastolic blood pressure (DBP).

## 2.2 | Definition of flap surgery outcomes

We followed patients who underwent flap-reconstruction surgery and extracted data regarding complete wound healing, major and minor complications, and recurrence. Complete wound healing is defined as a surgical site with no presentation of wound drainage or wound dehiscence 14 days after the removal of drainage tube. In addition, the duration from surgery to complete wound healing was recorded. Major complications were defined as surgical sites with an infection that required surgical debridement or poor healing that required additional flap-reconstruction surgery. Minor complications included wound dehiscence, infection only requiring antibiotics, and partial flap necrosis at the surgical site. Recurrence is defined as the wound that healed completely ever but newly onset of the wound required further surgery. Moreover, the duration from surgery to complications and mortality was recorded.

## 2.3 | Statistical analysis

The collected data were statistically analysed using the R Data Analysis & Guiding System (RDAGS). The descriptive

**TABLE 1** Patient demographics in this study

| | Total | Pre-COVID | COVID | *P* |
|---|---|---|---|---|
| Total no. of patient | 213 | 147 | 66 | |
| Sex | | | | 0.840 |
| Male | 99 (46.48%) | 69 (46.94%) | 30 (45.45%) | |
| Female | 114 (53.52%) | 78 (53.06%) | 36 (54.55%) | |
| Age (years) | | | | |
| Mean | 79.06 ± 13.53 | 78.87 ± 14.29 | 79.48 ± 11.73 | 0.760 |
| 0 to 18 | 0 (0.00%) | 0 (0.00%) | 0 (0.00%) | - |
| 19 to 39 | 2 (0.94%) | 2 (1.36%) | 0 (0.00%) | 0.341 |
| 40 to 59 | 16 (7.51%) | 12 (8.16%) | 4 (6.06%) | 0.590 |
| 60 to 79 | 69 (32.39%) | 47 (31.97%) | 22 (33.33%) | 0.844 |
| ≥80 | 126 (59.15%) | 86 (58.50%) | 40 (60.61%) | 0.772 |
| BMI ($kg/m^2$) | | | | |
| Mean | 20.48 ± 3.66 | 20.46 ± 3.25 | 20.52 ± 4.46 | 0.925 |
| <18.5 | 70 (32.86%) | 47 (31.97%) | 23 (34.85%) | 0.679 |
| 18.5 to 24 | 106 (49.77%) | 77 (52.38%) | 29 (43.94%) | 0.254 |
| >24 | 37 (17.37%) | 23 (15.65%) | 14 (21.21%) | 0.321 |
| Smoking status | 18 (8.45%) | 13 (8.84%) | 5 (7.58%) | 0.758 |
| Diabetes mellitus | 90 (42.25%) | 64 (43.54%) | 26 (39.39%) | 0.571 |
| Hypertension | 121 (56.81%) | 89 (60.54%) | 32 (48.48%) | 0.078 |
| Coronary artery disease | 49 (23.00%) | 34 (23.13%) | 15 (22.73%) | 0.948 |
| Haemodialysis | 25 (11.74%) | 18 (12.24%) | 7 (10.61%) | 0.731 |
| Parkinson's disease | 28 (13.15%) | 18 (12.24%) | 10 (15.15%) | 0.561 |
| Dementia | 51 (23.94%) | 28 (19.05%) | 23 (34.85%) | 0.012[a] |
| Follow-up duration (days) | 261.88 ± 410.33 | 322.47 ± 472.93 | 126.93 ± 141.31 | <0.001[a] |

*Note*: Data are presented as mean ± SD for continuous variables and n (%) for categorical variables. Pre-COVID period: January 2016 to December 2019; COVID period: January 2020 to December 2021.

[a]Statistically significant.

**TABLE 2** PI locations and NPUAP grades

| | Total | Pre-COVID | COVID | *P* |
|---|---|---|---|---|
| *Number of surgeries* | 464 | 308 | 156 | |
| Location | | | | |
| Sacrum | 239 (51.51%) | 170 (55.19%) | 69 (44.23%) | 0.025[a] |
| Back | 37 (7.97%) | 18 (5.84%) | 19 (12.18%) | 0.017[a] |
| Trochanter | 107 (23.06%) | 65 (21.10%) | 42 (26.92%) | 0.159 |
| Ischium | 45 (9.70%) | 37 (12.01%) | 8 (5.13%) | 0.017[a] |
| Elbow | 2 (0.43%) | 1 (0.32%) | 1 (0.64%) | 0.623 |
| Lower extremities | 34 (7.32%) | 17 (5.52%) | 17 (10.90%) | 0.035[a] |
| NPUAP grade | | | | |
| 1 | 0 (0.00%) | 0 (0.00%) | 0 (0.00%) | - |
| 2 | 9 (1.94%) | 4 (1.30%) | 5 (3.21%) | 0.159 |
| 3 | 79 (17.03%) | 53 (17.21%) | 26 (16.67%) | 0.883 |
| 4 | 364 (78.45%) | 244 (79.22%) | 120 (76.92%) | 0.569 |
| NA | 12 (2.59%) | 7 (2.27%) | 5 (3.21%) | - |

*Note*: Lower extremities include legs and feet. Pre-COVID period: January 2016 to December 2019; COVID period: January 2020 to December 2021.
Abbreviation: NPUAP, national pressure ulcer advisory panel.
[a]Statistically significant.

statistics—including patient demographic, blood tests, vital signs, and flap surgery outcome data—are presented as the number [proportion (%)] and mean ± standard deviation (SD). Student's *t* and chi-square tests were used for analysing the continuous and categorical variables, respectively. All recorded *P* values are two-sided; moreover, a *P* value of <0.05 was considered to indicate statistical significance.

## 3 | RESULTS

### 3.1 | Patient demographics

The study included a total of 213 patients with PIs. Of them, 99 (46.48%) were men and 114 (53.52%) were women; their mean age was 79.06 ± 13.53 years. Most of our patients were aged >80 years [n = 126 (59.15%)]. The mean BMI was 20.48 ± 3.66 kg/m$^2$; in most patients, the BMI was within the normal range [18.5-24 kg/m$^2$; 106 (49.77%)]. The most common underlying disease was hypertension [n = 121 (56.81%)], followed by diabetes mellitus [n = 90 (42.25%)] and dementia [n = 51 (23.94%)]. The mean follow-up duration was 261.88 ± 410.33 days.

The patient demographics during the pre-COVID and COVID periods did not differ significantly; the only exception was that compared with the pre-COVID period, the COVID period had significantly more patients with dementia [n = 23 (34.85%) vs n = 28 (19.05%), $P = 0.012$] and a significantly shorter follow-up duration [126.93 ± 141.31 vs 322.47 ± 472.93 days, $P < 0.001$] (Table 1).

### 3.2 | PI location and grade distribution

In total, 464 surgeries were performed on the 213 included patients; of them, 308 and 156 were performed during the pre-COVID and COVID periods, respectively. The surgeries were conducted on the sacrum, back, trochanter, ischium, elbow, or lower extremity PIs. The most frequent PI-related surgical site was the sacrum [n = 239 (51.51%)], followed by the trochanter [n = 107 (23.06%)] and the ischium [n = 45 (9.70%)].

Compared with the pre-COVID period, the COVID period had significantly fewer PI-related surgeries on the sacrum and ischium but significantly more PI-related surgeries on the back and lower extremities. The NPUAP grade of most of the included PIs was stage IV [n = 364 (78.45%)], and the differences in the NPUAP grades between the pre-COVID and COVID periods were non-significant (Table 2).

### 3.3 | Preoperative blood test results and vital signs in pre-COVID and COVID periods

The differences in the blood test results and vital signs between the pre-COVID and COVID periods were significant. Regarding the blood test results, the COVID period had more patients with WBC > 12 000/μL (24.03% vs 15.59%, $P = 0.029$) and higher mean CRP levels (7.13 ± 6.36 vs 5.58 ± 5.09 mg/dL, $P = 0.014$) but lower Hgb levels (9.75

**TABLE 3** Preoperative blood test results and vital signs

| | Total | Pre-COVID | COVID period | *P* |
|---|---|---|---|---|
| WBC | 9.25 ± 4.92 | 9.05 ± 4.21 | 9.63 ± 6.04 | 0.290 |
| >12 000/μL | 83 (18.48%) | 46 (15.59%) | 37 (24.03%) | 0.029[a] |
| ANC/μL | 7079.84 ± 4921.5 | 6779.26 ± 4309.19 | 7668.48 ± 5913.55 | 0.111 |
| ALC/μL | 1333.15 ± 756.54 | 1367.76 ± 749.17 | 1265.36 ± 768.88 | 0.187 |
| Hgb (g/dL) | 10.20 ± 1.82 | 10.43 ± 1.67 | 9.75 ± 2.02 | <0.001[a] |
| Platelet | 272.74 ± 112.02 | 270.65 ± 115.19 | 276.73 ± 105.93 | 0.589 |
| <150 000/μL | 51 (11.51%) | 36 (12.37%) | 15 (9.87%) | 0.433 |
| CRP (mg/dL) | 6.10 ± 5.59 | 5.58 ± 5.09 | 7.13 ± 6.36 | 0.014[a] |
| HbA1c | 6.90 ± 1.61 | 6.82 ± 1.60 | 7.02 ± 1.62 | 0.416 |
| Alb (≥2.5 g/dL) | 268 (63.35%) | 178 (64.26%) | 90 (61.64%) | 0.595 |
| Creatinine (mg/dL) | 1.11 ± 1.3 | 1.10 ± 1.24 | 1.12 ± 1.42 | 0.849 |
| ≥2 (mg/dL) | 52 (11.25%) | 37 (12.09%) | 15 (9.62%) | 0.426 |
| eGFR (≥60 mL/min/1.73 $m^2$) | 354 (76.62%) | 237 (77.45%) | 117 (75.00%) | 0.556 |
| BT (°C) | 36.57 ± 0.41 | 36.55 ± 0.43 | 36.60 ± 0.35 | 0.241 |
| PR (beats/min) | 83.12 ± 14.27 | 81.26 ± 13.66 | 86.67 ± 14.76 | <0.001[a] |
| >90 (beats/min) | 122 (27.98%) | 66 (23.08%) | 56 (37.33%) | 0.002[a] |
| RR (breaths/min) | 17.50 ± 2.27 | 17.31 ± 2.39 | 17.87 ± 1.98 | 0.009[a] |
| > 20 (breaths/min) | 23 (5.33%) | 15 (5.30%) | 8 (5.41%) | 0.963 |
| SBP (mmHg) | 127.68 ± 21.55 | 127.95 ± 20.51 | 127.15 ± 23.51 | 0.719 |
| DBP (mmHg) | 69.14 ± 14.66 | 69.07 ± 14.30 | 69.28 ± 15.39 | 0.884 |

*Note*: Data are presented as mean ± SD for continuous variables and n (%) for categorical variables. Pre-COVID period: January 2016 to December 2019; COVID period: January 2020 to December 2021.

Abbreviations: Alb, albumin; ALC, absolute lymphocyte count; ANC, absolute neutrophil count; BT, body temperature; CRP, C-reactive protein; DBP, diastolic blood pressure; eGFR, estimated glomerular filtration rate; HbA1c, glycated haemoglobin; Hgb, haemoglobin; PR, pulse rate; RR, respiratory rate; SBP, systolic blood pressure; WBC, white blood cell.

[a]Statistically significant.

± 2.02 vs10.43 ± 1.67 g/dL, $P < 0.001$). Regarding the vital signs, the COVID period had higher PR (86.67 ± 14.76 vs 81.26 ± 13.66 beats/min, $P < 0.001$), higher RR (17.87 ± 1.98 vs 17.31 ± 2.39, $P = 0.009$), and more patients with PR > 90 beats/min (37.33% vs 23.08%, $P = 0.002$) (Table 3).

## 3.4 | Flap surgery outcomes

During 2016 to 2021, 113 flap surgeries were conducted; of them, 88 (28.57%) and 25 (16.03%) were performed during the pre-COVID and COVID periods, respectively ($P = 0.002$). Moreover, 54 (47.79%) of these flap-reconstruction surgeries included ostectomy of bone prominence. The mean drainage retention period was 9.33 ± 5.95 days, whereas the mean hospital stay length was 25.17 ± 25.26 days.

In all 113 flap surgeries, 33 (29.20%) complications were noted; they comprised 16 major and 17 minor complications. Among the major complications, 11 (9.73%) infected wounds required additional surgical debridement and 5 (4.42%) poor healing wounds needed second flap reconstruction, respectively. Among the minor complications, 12 (10.62%) cases had wound dehiscence, 2 (1.77%) had infection, and 3 (2.65%) had partial flap necrosis; neither of them needed reoperation. The mean duration from surgery to minor complications was 22 ± 14.66 days. Finally, 94 (83.19%) flap surgery cases achieved complete wound healing after a mean duration from surgery of 32.94 ± 19.52 days. Recurrence occurred in seven (6.19%) cases, and mortality within 14 postoperative days was noted in six (5.13%) cases.

Regarding other flap surgery outcomes, the differences between the pre-COVID and COVID periods were nonsignificant (Table 4).

## 3.5 | Summary of significant results

- The demographic of patients before and after the COVID-19 pandemic showed no significant findings except there were more patients with dementia after the COVID pandemic period (Table 1).

**TABLE 4** Flap surgery outcomes

| | Total | Pre-COVID | COVID period | *P* |
|---|---|---|---|---|
| Total no. of surgery | 464 | 308 | 156 | |
| Total no. of flap surgery | 113 (24.35%) | 88 (28.57%) | 25 (16.03%) | 0.002[a] |
| Ostectomy | 54 (47.79%) | 43 (48.86%) | 11 (44.00%) | 0.667 |
| Total complication | 33 (29.20%) | 24 (27.27%) | 9 (36.00%) | 0.248 |
| Major complication | 16 (14.16%) | 11 (12.50%) | 5 (20.00%) | 0.339 |
| Average reoperation times | 1.81 ± 0.91 | 2.00 ± 1.00 | 1.40 ± 0.54 | 0.234 |
| Additional debridement | 11 (9.73%) | 9 (10.23%) | 2 (8.00%) | 0.094 |
| Second flap reconstruction | 5 (4.42%) | 2 (2.27%) | 3 (12.00%) | 0.094 |
| Minor complication | 17 (15.04%) | 13 (14.77%) | 4 (16.00%) | 0.743 |
| Wound dehiscence | 12 (10.62%) | 10 (11.36%) | 2 (8.00%) | 0.301 |
| Infection | 2 (1.77%) | 1 (1.14%) | 1 (4.00%) | 0.347 |
| Partial flap necrosis | 3 (2.65%) | 2 (2.27%) | 1 (4.00%) | 0.659 |
| Days from surgery to minor complication | 22 ± 14.66 | 24.38 ± 15.38 | 14.25 ± 9.77 | 0.238 |
| ≤7 days | 3 (2.65%) | 1 (1.14%) | 2 (8.00%) | 0.052 |
| ≤1 month (≤30 days) | 11 (9.73%) | 9 (10.23%) | 2 (8.00%) | 0.481 |
| ≤3 months (≤90 days) | 3 (2.65%) | 3 (3.41%) | 0 (0.00%) | 0.289 |
| Complete wound healing | 94 (83.19%) | 73 (82.95%) | 21 (84.00%) | 0.220 |
| Duration from surgery to healing (days) | 32.94 ± 19.52 | 31.36 ± 17.89 | 38.64 ± 24.27 | 0.175 |
| Recurrence | 7 (6.19%) | 5 (5.68%) | 2 (8.00%) | 0.666 |
| Death within 14 postoperative days | 6 (5.31%) | 3 (3.41%) | 3 (12.00%) | 0.090 |
| Drain retention period (days) | 9.33 ± 5.95 | 9.14 ± 6.22 | 10 ± 4.99 | 0.566 |
| Length of hospital stay (days) | 25.17 ± 25.26 | 25.87 ± 28.19 | 22.76 ± 9.81 | 0.389 |

*Note*: Data are presented as mean ± SD for continuous variables and n (%) for categorical variables. Pre-COVID period: January 2016 to December 2019; COVID period: January 2020 to December 2021.

[a]Statistically significant.

- Compared with the pre-COVID period, the COVID period had significantly fewer PI-related surgeries on the sacrum and ischium but significantly more PI-related surgeries on the back and lower extremities (Table 2).
- In the COVID period, there were significantly more patients with WBC >12 000/μL, elevated CRP (mg/dl), low Hgb, higher pulse rate and higher respiratory rate compared with the pre-COVID period (Table 3).
- The number of flap surgeries has significantly decreased after the COVID pandemic period. As for the flap outcome, there is no significant difference before and after COVID (Table 4).

This study found that during the COVID-19 pandemic, most of the included patients with PIs demonstrated poor control of infection, inflammation, and anaemia as well as unstable vital signs, and it delayed the appropriate timing for patients with PI to undergo flap surgery.

## 4 | DISCUSSION

### 4.1 | Reduced admission and delayed medical treatment during the COVID-19 pandemic

COVID-19 is a fast-spreading disease that had posed many psychological stressors in people's lives. The fear of being get infected led to the alteration of normal life. People ceased their participation in social activity, and avoided medical care, regardless of urgent or routine care due to the concern of COVID-19 disease. The consequence of delayed treatment can lead to numerous issues. In general, patients tend to ignore discomfort and wait until they feel unbearable symptoms before they visit the hospital. This may have been the reason for reducing the number of admissions and worsening disease treatments and prognoses during the pandemic. Specifically, a study revealed a substantial reduction in in-patient oncology admissions during the COVID-19 pandemic.[17] Another

study revealed a significant decrease in the number of emergency medical service responses across the United States during the early stages of the COVID-19 outbreak.[18] Similarly, De Filippo et al.[19] demonstrated a significant decrease in acute coronary syndrome–related hospitalisation rates across several cardiovascular centres during the early days of the pandemic. Similarly, another report revealed significantly longer treatment delay and higher T classifications for oral cancer after 2020 at Heidelberg University Hospital.[5] Delays in screening, diagnosis, and treatment were also found for colorectal cancer.[20-22]

### 4.2 | Impact of delayed medical treatment on patients with PIs during COVID-19

In patients with PIs, timely medical evaluation and treatment are essential. Superficial PIs, such as those graded NPUAP stages I or II, are the most common and preventable.[23] PI-related wounds may be dealt with by change in dressing, nutritional support, offloading, an air- or fluid-filled mattress, or cushions; hence, seeking immediate medical assistance is necessary for patients with PIs.[24,25] Conversely, delayed medical treatment may worsen the condition of PI wounds. Moreover, patients with PIs require more considerable care; reduced availability of nursing and medical resources, such as happened during the COVID-19 pandemic, may also further worsen the condition of patients with PIs.[26]

### 4.3 | Increase in the proportion of dementia patients to undergo PIs surgery during COVID-19

First, the increase in the proportion of dementia was significant in our patients during the COVID period. Dementia can result in motor, sensory, autonomic, cognitive, or behavioural changes that predispose the affected patients to PI.[27] The median survival years of patients with PIs and advanced dementia concomitantly was significantly shorter.[14] Carbone et al.[28] reported a considerable increase in the psychological and physical burden of caregivers of patients with cognitive impairment or dementia during COVID-19 confinement and an overall worsening of the clinical condition of patients with dementia. The multifaceted health needs of patients with dementia were largely neglected during the emergency phases of the COVID-19 pandemic.[29] We propose that during the pandemic, the increased burden among the caregivers, social isolation, and physical restraint all led to insufficient care and deteriorated cognitive and motor function among dementia patients with PIs and resulted in a relative increase in the number of hospital admissions.

### 4.4 | Altered distribution of PIs surgical location during COVID-19

In our study, the proportion of surgeries on the sacrum and ischium was significantly lower, but the proportion of those on the back and lower extremities was significantly higher during the COVID period. Ischium is a location of PIs among patients who stay in the sitting position, usually in a wheelchair, for long durations.[30] In comparison, patients who are bedridden for a long time with lower Braden scale scores generally have PIs on their back or lower extremities. Lahmann et al.[31] reported that in both acute hospital care and nursing home facilities, the most common locations of PIs were the lower back and heels in patients with a Braden score $\leq 20$. Moreover, patients with a lower Braden score tend to have more severe PIs. Similarly, Han et al.[32] indicated that chronic untreated PIs on the heel of patients in nursing homes occur frequently in bedridden patients with lower-extremity contractures and that such patients have an increased risk of eventual amputation. Another study reported a higher ratio of NPUAP stage 3 and 4 PIs on the foot, ankle, and crus of the lower legs.[33] Taken together, these results indicated that patients with PIs on the back and lower extremities had a generally poor functional level and worsened wound condition. During the COVID-19 pandemic, the increased proportion of PI locations on the back and lower extremities was possibly due to more severe patient conditions, resulting in unavoidable hospital admissions.

### 4.5 | Poor control of infection, inflammation, and anaemia in patients with PIs during COVID-19

The blood test analysis further supported our hypothesis that patients were presented to our service under more severe circumstances during the pandemic. A significant increase was noted in the proportion of patients with WBC $> 12\,000/\mu L$ and elevated CRP levels, indicating poor inflammation and infection control. Edsberg et al.[34] reported that infection and inflammation can not only affect tissue healing but also reduce the serum albumin level, which is a negative acute-phase reactant in the presence of inflammation. In our study, among all 83 patients with WBC $> 12\,000/\mu L$, 75 (90.36%) patients had a decreased Alb level of <3.5 g/dL. This confirmed that poor inflammation control further induces malnutrition status,

eventually affecting PI prognosis. Moreover, Hgb levels in the patients with PIs decreased significantly during the COVID period. Hgb is a vital oxygen carrier in the human body. Reduced Hgb levels can cause poor wound healing because of insufficient oxygen supply, consequently affecting PI prognosis.[35,36] Also, decreased Hgb level is a potential risk factor for developing PI,[36] and may reflect the overall compromised health status of patients during the COVID-19 pandemic.[34]

### 4.6 | Unstable vital signs of patients with PIs during COVID-19

Regarding vital signs, both the PR and RR of patients with PIs increased significantly during the pandemic. Our study also demonstrated an increased proportion of patients with PR > 90 beats/min during the COVID period. Satty et al.[37] reported a similar result in western Pennsylvania, USA: patients tended to have a slightly worsened condition during the COVID period, which was accompanied by increases in the proportions of patients with tachycardia, tachypnea, or <95% oxygen saturation (measured through pulse oximetry). This confirmed that patient conditions were generally unstable during the COVID-19 pandemic and corroborated our results regarding insufficient Hgb and poor infection control, which may lead to poor vital signs.

### 4.7 | Catastrophic consequences result from COVID-19 in several aspects

In summary of our study, changes in public behaviour, willingness to be hospitalised, and medical resource availability may have led to a generally poor and unstable status in patients with PIs during the pandemic. These changes may have catastrophic consequences for patients with PIs and negative effects in many other aspects. A retrospective study demonstrated that PI severity worsened during the COVID period.[38] By contrast, a multicenter retrospective cohort demonstrated that patients with hip fractures during the pandemic had low Charlson comorbidity index and American Society of Anesthesiologists scores.[39] In addition, Lim et al.[40] reported that patients with out-of-hospital cardiac arrest had a reduced admission survival rate and discharge survival rate and less favourable neurological outcomes during the COVID period. Another study demonstrated an increase in mortality occurring outside of medical facilities during the COVID period.[41] All these studies confirmed the considerable effect of the COVID-19 pandemic in worsening health-related outcomes. In our study, although the difference in outcomes in the flap surgery during the COVID period was nonsignificant, there was still a significantly decreased proportion of flap surgery noted. We propose that the decrease in flap surgeries was due to general untreated conditions in patients with PIs, for whom effective inflammation and infection control and a high Hgb level are prerequisites to flap surgery.

### 4.8 | Holistic management

During the COVID-19 pandemic, an inability to administer appropriate management and treatment of patients became a major problem. Holistic treatment may be a suitable solution for this problem. Such an approach would focus on providing high-quality care to meet patients' individual needs. In particular, patients with PIs require "person-centred care", which must involve not only wound treatment but also improvements in patient care attitude, communication, and education. The success of a holistic assessment is predicated on the ability to connect, communicate, and understand patients in ways beyond interpreting physical signs or symptoms.[42] We previously reported that a good holistic approach for patients with PIs must include close outpatient clinic care and admission care.[43] Not only the plastic surgeon but also the case manager, anesthesiologist, infectious physician, and main caregiver must be part of the treatment team to provide a thorough evaluation and education. The nutrition, infection, and anaemia statuses must be corrected before surgery is performed. Before surgery, the underlying diseases must be managed, and the wound bed should be well-prepared. In general, we suggest that a holistic approach is the most appropriate for the effective treatment and management of PIs during a COVID-19-like pandemic.

### 4.9 | Limitations

This study has some limitations. First, this was a single-centre study with a limited number of patients with PIs. Second, the number of patients and research duration between the pre-COVID and COVID periods were not identical, which may have affected our final results. Furthermore, we could not track patients who were admitted to other hospitals. Lastly, during the COVID period, the frequency of hospital visits was difficult for patients, particularly for those with PIs who were bedridden. This situation disrupted routine patient visits; moreover, in many cases, physicians assessed patient condition virtually through online consultation or based on a photograph brought in by family members; this may have affected our evaluation, particularly possible misdiagnosis of PIs.

## 5 | CONCLUSION

During the COVID-19 pandemic, most of the included patients with PIs demonstrated poor control of infection, inflammation, and anaemia as well as unstable vital signs, and it delayed the appropriate timing for patients with PI to undergo flap surgery. Thus, during the COVID-19 pandemic, thorough early management and correction of patient conditions are an urgent need. Holistic care may be the most appropriate management strategy for improving the prognosis of patients with conditions such as PIs during a pandemic-like period.

### AUTHOR CONTRIBUTIONS

Study conception and design: Wen-Kuan Chiu, Chiehfeng Chen, Hsian-Jenn Wang; Methodology: Ching-Ya Huang, Jin-Hua Chen; Acquisition of data: Ching-Ya Huang, Sheng-Lian Lee; Analysis and interpretation of data: Ching-Ya Huang, Jin-Hua Chen, Wen-Kuan Chiu; Drafting of manuscript: Ching-Ya Huang, Sheng-Lian Lee; and Critical revision of manuscript: Ching-Ya Huang, Chiung-Wen Chang, Sheng-Lian Lee, Jin-Hua Chen, Wen-Kuan Chiu, Chiehfeng Chen, Hsian-Jenn Wang.

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### CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

### DATA AVAILABILITY STATEMENT

Data is not available on request due to privacy/ethical restrictions.

### ETHICS STATEMENT

Approval for this study was given by the Taipei Medical University-Joint Institutional Review Board (N202204045).

### PROVENANCE AND PEER REVIEW

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