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EMPIRICAL RESEARCH QUANTITATIVE

Incidence and characteristics of hospital-acquired mucous membrane pressure injury: A five-year analysis

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Abstract

Background: Pressure injuries on mucous membranes are caused by pressure from medical devices at the site of injury and differ to those on the skin. Intensive care patients, who have multiple devices in situ, are particularly vulnerable. There is a significant knowledge gap regarding mucous membrane pressure injury (MMPI) incidence in acute hospital settings.

Aim: To analyse MMPI incidence and characteristics in a tertiary acute general hospital.

Methods: A secondary data analysis of hospital clinical incident reports was conducted. The sample included all adults with MMPIs between 2015 and 2019. The STROBE reporting guideline was followed.

Results: There were 414 reports of MMPI. Most (91.5%, $n = 379$) were hospital-acquired with the majority found in intensive care patients (74.4%, $n = 282$). Hospital-acquired MMPI incidence was 0.1% (11 MMPI per 10,000 hospital episodes). In intensive care, the incidence was 2.4% (235 MMPI per 10,000 intensive care episodes). The median time from device insertion until reporting of an MMPI was 3 days. The most common sites of mucosal injury were the lips (35.6%) and mouth (28.8%). In all cases except one, MMPI was associated with medical device use at the site of injury. Five device types were identified (oral endotracheal tube-related 70.3%; urinary catheter 15.5%; gastric tube 8.3%; nasal prongs 3.5%; tracheostomy tube 2.4%). In intensive care, oral endotracheal tube-related devices were most often associated with MMPI (84.8%), whereas in non-intensive care MMPI it was the urinary catheter (51.4%).

Conclusions: While hospital-acquired MMPI incidence is relatively low, it is considerably higher in intensive care patients compared to those in non-intensive care settings. The most common sites are the lips and mouth.

Relevance to clinical practice: Mucous membrane pressure injuries represent a significant proportion of all hospital-acquired pressure injuries.

Patient or public contribution: Neither patients nor the public were directly involved in this project.

KEYWORDS
critical care, hospitals, incidence, mucous membrane, patients, pressure injury, pressure ulcer

1 | INTRODUCTION

Pressure injuries have the potential to negatively impact patients, their carers and organisational healthcare providers (Bauer et al., 2016; Burston et al., 2022; Nghiem et al., 2022), and are considered a source of preventable harm when occurring as a complication of hospitalisation (Fernando-Canavan et al., 2021). As such, hospital-acquired pressure injury prevention is a key component of patient safety, with pressure injury occurrence commonly used as an indicator of healthcare quality (Weller et al., 2018). Nevertheless, despite the availability of international recommendations and practice guidance for pressure injury prevention (EPUAP, NPIAP & PPPIA, 2019) and efforts to decrease their occurrence, they continue to be a healthcare burden within the hospital setting and its sub-populations (Källman et al., 2022; VanGilder et al., 2021).

Pressure injuries occur as a result of localised pressure, or pressure with shear, applied to soft tissues, with such forces applied by either a patient's own body weight (e.g., against a bed or chair surface) or an external device or object (e.g., a medical device exerting pressure on the skin tissue) (EPUAP et al., 2019). For pressure injuries that develop on the skin, there is an international classification system that involves six pressure injury stages (or categories): Stage I (non-blanchable erythema), Stage II (partial thickness skin loss), Stage III (full thickness skin loss), Stage IV (full thickness tissue loss), Unstageable (depth unknown) and Suspected Deep Tissue Injury (depth unknown) (NPUAP et al., 2014). The system was updated in the United States in 2016, with updates including changes to terminology (e.g., pressure ulcer to pressure injury), revised pressure injury definitions and aetiology (e.g., recognition/definition of medical device-related pressure injury) and use of Arabic instead of Roman numerals (Edsberg et al., 2016). However, because these systems are based upon skin anatomy, divergences between skin and mucosal tissues prevent their use for classifying pressure injuries that develop on mucous membranes (Edsberg et al., 2016; EPUAP et al., 2019; Mucous Membrane Task Force, NPUAP, 2008). Indeed, non-blanchable erythema (i.e., Stage I pressure injury) is unable to be visualised in the mucous membranes, nor can the depth of an injury (e.g., shallow, superficial versus deeper and full thickness) be discerned (Edsberg et al., 2016; Mucous Membrane Task Force, NPUAP, 2008). Additionally, soft clots formed as a result of a mucosal injury bleeding may be mistaken for the slough of a Stage III pressure injury, and exposed muscle and bone which are markers for Stage IV pressure injury, would often not be seen or present, respectively (Mucous Membrane Task Force, NPUAP, 2008).

Mucous membrane pressure injury (MMPI) is associated with a history of medical device use at the site of the injury (Edsberg et al., 2016; Mucous Membrane Task Force, NPUAP, 2008), and it is suggested that it should be labelled as such, with its corresponding location and associated device recorded (Edsberg et al., 2016). Recently, a consensus document on device-related PI aetiology, causes, management and prevention has been developed (Gefen et al., 2020), and since updated (Gefen et al., 2022), with the intention of prompting action to improve patient outcomes and safety in relation to these injuries. Within the hospital setting, critically ill patients are particularly vulnerable to medical device-related pressure injury and MMPI given the more frequent use of medical devices within intensive care units (Coyer et al., 2017). However, although the incidence and prevalence of hospital- and intensive care-acquired pressure injury are widely reported, there are few studies that have reported MMPI as a category of pressure injury. The reporting accuracy of MMPI is not clear, and it is likely that many may be inappropriately reported and staged as skin injuries. A systematic review examining the incidence and prevalence of MMPI in acute care hospitals concluded that there was insufficient evidence available to enable estimation of MMPI incidence or prevalence (Fulbrook et al., 2022). The authors found that, out of 21 included studies, none specifically reported MMPI as an outcome measure, and MMPI incidence or prevalence was only able to be calculated from four studies. The calculated MMPI incidence and prevalence was highly variable in

What does this paper contribute to the wider global community?

- This study is the first to undertake a rigorous analysis of hospital-acquired mucous membrane pressure injury incidence within an acute hospital setting. The results can be used by facilities for benchmarking purposes in acute hospital settings, and in non-intensive care and intensive care sub-sets.
- The incidence of mucous membrane pressure injury was low across the hospital setting, but it represents a clinically significant issue that impacts patients, especially those in intensive care, where incidence is much higher, and the use of medical devices is greater.
- The use of preventative measures is essential to reduce the incidence of hospital-acquired pressure injury, and the results of this study may be used to inform targeted strategies to reduce mucous membrane pressure injury. In particular, the results indicate that the devices most commonly associated with mucous membrane pressure injury, which require prophylactic care, are endotracheal tube-related devices, urinary catheters and gastric tubes.

intensive care, with incidence rates of 0.8% (Alves et al., 2017) and 30.4% (Coyer et al., 2015) and prevalence rates of 1.7% (Coyer et al., 2014) and 3.7% (Coyer et al., 2017). In one study only, a prevalence of 0.1% was able to be calculated in a non-intensive care sample (Coyer et al., 2017). Similarly, a systematic review of medical device-related pressure injury incidence in acute hospital settings found no reports of MMPI (Brophy et al., 2021), while conversely, a review focused on intensive care found that MMPI was the most commonly reported 'stage' of pressure injury in incidence studies (Barakat-Johnson et al., 2019).

Overall, the review of Fulbrook et al. (2022) has highlighted a significant gap in knowledge regarding MMPI, with a lack of studies reporting MMPI incidence in both acute hospital and intensive care settings. Thus, it is difficult to determine the true extent to which MMPI impacts the hospitalised population. The lack of specific MMPI reporting has implications for healthcare institutions, making benchmarking and improvement of MMPI detection and prevention practices challenging. Therefore, the aim of this study was to analyse MMPI incidence and characteristics in a tertiary acute general hospital in Queensland, Australia, over a five-year period.

2 | METHODS

2.1 | Design

A secondary data analysis of hospital clinical incident reports of MMPI was conducted. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE, 2022) checklist was used to guide reporting (Supplementary File 1).

2.2 | Setting and sample

The setting was a 663-bed tertiary general hospital in south-east Queensland, Australia, in which all pressure injuries were reported via its clinical incident monitoring system. For the purpose of this study, all adult (≥18 years) inpatients that were reported to have a MMPI were included in the sample. Approval for use of the data for this study was granted by the relevant data custodians, and ethical exemption was obtained from the hospital's research ethics committee (ref: HREC/18/QPCH/258).

2.3 | Data collection

In the study hospital, pressure injuries reported via the clinical incident reporting system are reviewed visually and validated by specialist nurses from the Quality Effectiveness Support Team (QuEST) to confirm their presence, location and stage or category. The incident report and specialist nurse review (including correction of initial pressure injury staging/categorisation) are documented in a hospital-wide audit database held by QuEST. For the purpose of this study, all identified and validated MMPI between the years 2015 to 2019 were extracted from the audit database. The validated MMPI from the audit database were cross-checked against databases of all pressure injury clinical incident reports logged during the study period, which were provided by the hospital's *Coordinator Clinical Incidents—Safety and Quality Unit*, and any unvalidated pressure injuries logged as an MMPI were also included. All data were provided in Microsoft Excel™ databases, where they were collated, checked and cleaned before being imported into IBM SPSS™ (version 28) for statistical analysis. Any discrepancies in the data were checked and amended as necessary, following review of patient charts and cross-checking of the original clinical incident data. Device insertion dates were retrieved directly from patients' charts.

2.4 | Data analysis

Descriptive statistics were used to describe sample characteristics. Means (*M*) with standard deviation (*SD*) are used to describe central tendency of scale data and medians (Md) with interquartile range (IQR) and proportions used to describe ordinal and categorical variables. Inferential statistics were used to analyse sample differences. Time intervals were calculated within SPSS™ based on dates and measured in whole days. As time intervals were not exact, central tendency is described using Md (IQR). *T*-tests were used to analyse differences in scale variables, and Fisher's exact test was used for categorical variables. Significance was set at $p < .05$.

Hospital-acquired MMPI incidence was calculated as: [(numerator ÷ denominator) × 100%], where the numerator was defined as the number of unique hospital admissions (episodes) in which the patient developed at least one hospital-acquired MMPI and the denominator was defined as the number of hospital admissions (episodes) during the same period (2015–2019). As the overall incidence proportion was very small, the MMPI rate is described per 10,000 hospital episodes. Due to the relatively large proportion of hospital-acquired MMPI in intensive care, a sub-set analysis of this group was conducted.

3 | RESULTS

Across the five years of data collection, 414 MMPI were reported in adults via the hospital clinical incident report system and QuEST. Of these, the majority (91.5%, $n = 379$) was hospital-acquired. There was a total of 314 unique incident reports of hospital-acquired MMPI, each reporting between 1 to 4 MMPI. The MMPI were reported in 296 different hospital admission episodes. Three quarters of all hospital-acquired MMPIs (74.4%, $n = 282$) were reported when the patient was in the intensive care. Three patients had MMPIs reported in both a general ward and intensive care during the same hospital episode.

A large majority of hospital-acquired MMPI was validated by QuEST as such (96.3%, $n = 365$). Based on chart review, the

TABLE 1 Hospital-acquired MMPI annual incidence

	Admissions (episodes)									
	Non-ICU			ICU			Overall			
Year	Total *n* (%)	MMPI *n* (%)	MMPI per 10,000 hospital episodes (incidence %)	Total *n* (%)	MMPI *n* (%)	MMPI per 10,000 ICU episodes (incidence %)	Total *n* (%)	MMPI *n* (%)	MMPI per 10,000 hospital episodes (incidence %)
2015	44,112 (17.2)	14 (16.7)	3.2 (.03)	1669 (18.4)	61 (28.5)	365.4 (3.7)	45,781 (17.3)	75 (25.3)	16.3 (.16)
2016	47,493 (18.5)	18 (23.1)	3.8 (.04)	1813 (19.9)	33 (15.4)	182.0 (1.8)	49,306 (18.6)	51 (17.2)	10.3 (.10)
2017	52,116 (20.3)	22[a] (23.1)	4.2 (.04)	1811 (19.9)	47 (22.0)	259.5 (2.6)	53,925 (20.3)	67 (22.6)	12.4 (.12)
2018	55,148 (21.5)	11 (12.8)	1.9 (.02)	1828 (20.1)	29 (13.6)	158.6 (1.6)	56,976 (19.2)	40 (13.5)	7.0 (.07)
2019	57,437 (22.4)	20[a] (24.4)	3.5 (.03)	1972 (21.7)	44[a] (20.6)	223.1 (2.2)	59,408 (22.4)	63 (21.5)	10.6 (.11)
TOTAL	256,245 (100)	85[a] (100)	3.3 (.03)	9093 (100)	214 (100)	235.3 (2.4)	265,396 (100)	296 (100)	11.1 (.11)

Abbreviation: ICU, intensive care unit.

[a]In 2017, there were two patients and one patient in 2019 who had MMPI in both a ward and ICU during the same hospital episode.

remaining injuries (n = 14) were also confirmed as MMPI. Of the MMPI reviewed by QuEST, just over half (51.8%, n = 189/365) was reviewed within 1 day (Md = 1, IQR 1–2) and three quarters were reviewed within 2 days (75.3%, n = 275). Information about the presence of an associated medical device was missing in four cases, and an MMPI was caused by the patient's own skin pressing against a vaginal prolapse in another. In all other cases (n = 374), the MMPI was associated with the presence of a medical device.

3.1 | Sample characteristics

The mean age of the sample was 62.9 years (*SD* 16.5, range 19–95, n = 296) but intensive care patients were younger (*M* 60.1, *SD* 16.2) than non-intensive care patients (*M* 70.0, *SD* 15.0; $p < .001$). The majority of the sample were males (72.1%, n = 212/294), who were older (*M* 64.2, *SD* 15.6 years) than females (*M* 59.3, *SD* 18.2; $p = 0.035$). The mean body mass index (BMI) of the sample was 28.9 (*SD* 8.8, n = 231) and a third was categorised as obese (BMI ≥ 30; 34.6%, Md = above average, n = 80/231) but there was no difference in BMI between males (*M* 29.0, *SD* 7.9) and females (*M* 28.5, *SD* 10.7; p = .730). However, BMI was higher in intensive care patients (*M* 29.7, *SD* 9.0) than non-intensive care patients (*M* 26.6, *SD* 7.7; p = .017). The most common primary diagnoses, according to International Classification of Diseases (ICD)-10 codes (World Health Organisation, 2019), were *IX Diseases of the circulatory system* (58.0%, n = 156) and *X Diseases of the respiratory system* (15.2%, n = 41); accounting for nearly three quarters (73.2%) of all hospital episodes.

3.1.1 | Incidence of hospital-acquired MMPI

Between 2015–2019, at least one MMPI per episode was reported in a total of 296 hospital episodes, giving an overall hospital-acquired MMPI incidence of 0.1% (11 MMPI per 10,000 hospital episodes). In the same period, there were 214 intensive care episodes in which at least one MMPI per episode was reported, giving an intensive care hospital-acquired MMPI incidence of 2.4% (235 MMPI per 10,000 intensive care episodes) (See Table 1).

3.1.2 | Time-to-MMPI

The time interval until a MMPI developed was calculated based on the recorded date of the medical device insertion until the date of the incident report, measured in whole days. The median time-to-MMPI was 3 days (IQR 1–5; range 0–37, n = 275) but varied by associated device (see Table 2). Over half (55.3%, n = 152) of all MMPI occurred within 3 days of device insertion and three quarters (75.6%, n = 208) occurred within 5 days.

In intensive care, the date of device insertion was not recorded in 67 cases. In the remainder (n = 238), the median time-to-MMPI following device insertion was 3 days (IQR 1–5; range 0–33) but varied

TABLE 2 Time-to-MMPI by device

Device type		n	Median (IQR)	Range
Oral endotracheal tube-related device	Non-ICU	5	2 (0–5)	0–8
	ICU	215	2 (1–4)	0–18
	Overall	220	2 (1–4)	0–18
Urinary catheter	Non-ICU	15	5 (1–14)	0–37
	ICU	11	14 (7–19)	5–33
	Overall	26	9 (4.5–15.3)	0–37
Gastric tube (nasal/oral)	Non-ICU	12	7 (5.3–14.3)	2–21
	ICU	6	4 (1–9.5)	1–14
	Overall	18	6.5 (3.8–12.5)	1–21
Nasal prongs	Non-ICU	5	8 (7–15.5)	6–17
	ICU	0	–	–
	Overall	5	8 (7–15.5)	6–17
Tracheostomy tube	Non-ICU	0	–	–
	ICU	6	11 (3.5–22.3)	2–23
	Overall	6	11 (3.5–22.3)	2–23
All	Non-ICU	37	6 (2–13.5)	0–37
	ICU	238	3 (1–5)	0–33
	Overall	275	3 (1–5)	0–37

Note: Missing $n = 103$.

Abbreviation: ICU, intensive care unit.

by associated device (see Table 2). The majority of all intensive care MMPI (58.8%, $n = 140/238$) were reported within 3 days of device insertion, compared to only a third of all non-ICU MMPIs (32.4%, $n = 12/37$) within the same time frame. Furthermore, in intensive care, with respect to oral endotracheal tube-related devices, half (51.2%, $n = 110/215$) of all MMPI occurred within 2 days of device insertion, with over three quarters (79.1, $n = 170/215$) occurring within 4 days. A third (33.3%%, $n = 5/15$) of urinary catheter-related MMPI occurred within 2 days of device insertion, with 60.0% occurring within 5 days ($n = 9/15$). Two thirds (66.7%, $n = 4/6$) of gastric tube-related MMPI occurred within 4 days, and half (50.0%, $n = 3/6$) of tracheostomy tube-related MMPI occurred within 8 days.

3.1.3 | Characteristics of hospital-acquired MMPI

A total of 379 hospital-acquired MMPI was reported, of which most (80.5%, $n = 305$) were reported in intensive care patients. Of the MMPI that were validated as MMPI by QuEST (96.3%, $n = 365$), the pressure injury category was recorded correctly in the initial incident report in the majority of cases (83.8%, $n = 306$). Of those that were not initially categorised correctly ($n = 59$), most (61.0%, $n = 36$) were categorised as Stage II pressure injuries. These were located on the genitals (36.1%, $n = 13$), nose (27.8%, $n = 10$), mouth (19.4%, $n = 7$), lips (13.9%, $n = 5$) and neck/tracheostomy site (2.8%, $n = 1$). A greater proportion of intensive care MMPI (89.5%) were initially classified correctly compared to non-intensive care MMPI (63.5%; $p < .001$) (See Table 3).

TABLE 3 Validated MMPI: Initially reported PI stage/category

Initially reported PI stage/category	Non-ICU n (%)	ICU n (%)	Total n (%)
Stage I	6 (8.1)	9 (3.0)	15 (4.0)
Stage II	16 (21.6)	20 (6.6)	36 (9.5)
Stage III	1 (1.4)	2 (0.7)	3 (0.8)
Stage IV	0 (0)	0 (0)	0 (0)
SDTI	2 (2.7)	0 (0)	2 (0.5)
Unstageable	2 (2.7)	1 (0.3)	3 (0.8)
Mucous membrane	47 (63.5)	273 (89.5)	320 (84.4)
Total number of validated mucous membrane pressure injuries	74 (100)	305 (100)	379 (100)

Abbreviations: ICU, intensive care unit; PI, pressure injury.

Of 379 MMPI, most were found on the lips (35.6%, $n = 135$) or mouth (28.8%, $n = 109$) and in intensive care the majority of MMPI were also found on the lips (42.6%, $n = 130/305$) or mouth (35.1%, $n = 107/305$). The most common (70.3%, $n = 263/374$) medical device associated with MMPI was oral endotracheal tube-related (tube, tape, attachment device, bite block/mouth guard), and in intensive care, it was also the most common (84.8%, $n = 256/302$) medical device associated with MMPI. In non-intensive care MMPI, the majority occurred on the genitals (52.7%, $n = 39/74$) or nose (37.8%, $n = 28/74$) and most MMPI were related to the presence of urinary catheters (51.4%, $n = 37/72$), gastric tubes (20.8%, $n = 15/72$) or nasal prongs (18.1%, $n = 13/72$). Of the 7 endotracheal tube-related device MMPI found in non-intensive care patients, they were reported to have occurred in the operating theatre ($n = 3$), emergency department ($n = 2$), coronary care unit ($n = 1$) and cardiac surgical ward ($n = 1$). The type of device associated with the MMPI and the site of the MMPI were both recorded in 374 cases (See Table 4).

4 | DISCUSSION

While some other studies have reported some data about MMPI prevalence or incidence in intensive care and device-related incidence studies, to our knowledge, this study is the first to undertake a rigorous analysis of hospital-acquired MMPI incidence across an acute hospital setting. In the absence of other studies on this topic, our results provide MMPI incidence rates for an acute hospital setting, and for non-intensive care and intensive care sub-sets, which can be used by facilities nationally and worldwide for benchmarking purposes. This study is also clinically relevant, as the results may be used to inform MMPI prevention practice.

Overall, across five years, we found a hospital-acquired MMPI incidence of 0.1%. However, the incidence of .03% found in non-intensive care patients was extremely low, and is even lower than the prevalence calculated (0.1%) from one Australian study across four years in eighteen hospitals (Coyer et al., 2017) in a recent systematic review (Fulbrook et al., 2022). In contrast, in the intensive

TABLE 4 Hospital-acquired MMPI: Site

Device		MMPI location						Totals		
		Neck	Mouth	Tongue	Lips	Nose	Genitals	Non-ICU	ICU	Overall
Oral endotracheal tube-related device	Non-ICU	–	2 (28.6) (1.9)	–	5 (71.4) (3.8)	–	–	7 (100) (9.7)	–	–
	ICU	–	106 (41.4) (98.1)	22 (8.6) (100)	127 (49.6) (96.2)	1 (0.4) (100)	–	–	256 (100) (84.8)	–
	Overall	–	108 (41.1) (100)	22 (8.4) (100)	132 (50.2) (100)	1 (0.4) (100)	–	–	–	263 (100) (70.3)
Urinary catheter	Non-ICU	–	–	–	–	–	37 (100) (63.8)	37 (100) (51.4)	–	–
	ICU	–	–	–	–	–	21 (100) (36.2)	–	21 (100) (7.0)	–
	Overall	–	–	–	–	–	58 (100) (100)	–	–	58 (100) (15.5)
Gastric tube (nasal/oral)	Non-ICU	–	–	–	–	15 (100) (53.4)	–	15 (100) (20.8)	–	–
	ICU	–	–	1 (6.3) (100)	2 (12.5) (100)	13 (81.3) (46.4)	–	–	16 (100) (5.3)	–
	Overall	–	–	1 (3.2) (100)	2 (6.5) (100)	28 (90.3) (100)	–	–	–	31 (100) (8.3)
Nasal prongs	Non-ICU	–	–	–	–	13 (100) (100)	–	13 (100) (18.1)	–	–
	ICU	–	–	–	–	–	–	–	–	–
	Overall	–	–	–	–	13 (100) (100)	–	–	–	13 (100) (3.5)
Tracheostomy tube	Non-ICU	–	–	–	–	–	–	–	–	–
	ICU	9 (100) (100)	–	–	–	–	–	–	9 (100) (3.0)	–
	Overall	9 (100) (100)	–	–	–	–	–	–		9 (100) (2.4)
Totals	Non-ICU	–	2 (2.8) (1.9)	–	5 (6.9) (3.7)	28 (38.9) (66.7)	37 (51.4) (63.8)	72 (100) (100)	–	–
	ICU	9 (3.0) (100)	106 (35.1) (98.1)	23 (7.6) (100)	129 (42.7) (96.3)	14 (4.6) (33.3)	21 (7.0) (36.2)	–	302 (100) (100)	
	Overall	9 (2.4) (100)	108 (28.9) (100)	23 (6.1) (100)	134 (35.8) (100)	42 (11.2) (100)	58 (15.5) (100)	–	–	374 (100) (100)

Note: Missing $n = 4$.

Abbreviation: ICU, intensive care unit.

care sample in our study, MMPI incidence (2.4%) was much greater. In other studies, MMPI incidence in intensive care has been variable. The systematic review of Fulbrook et al. (2022) calculated an MMPI incidence rate of 0.8% from a retrospective Portuguese intensive care study (Alves et al., 2017), while there was a much higher rate of 30.4% calculated from the 'before' period of an Australian study testing an interventional skin integrity bundle in intensive care (Coyer et al., 2015). Prevalence has generally been reported as low, with rates calculated as being 1.7% in a prospective study within two medical centres (Australia and the United States; Coyer et al., 2014) and 3.7% in the study by Coyer et al. (2017). Similarly, a more recent analysis of pressure injury data between the years 2015 and 2019 (P. Fulbrook, J. Lovegrove, F. Coyer, unpublished) from the same 18 Australian hospitals examined by Coyer et al. (2017) between 2012 and 2014 found a cumulative MMPI prevalence of 1.6% in intensive care. Meanwhile, a prospective study across 44 Australian and New Zealand intensive care units reported only one MMPI in 624 patients, resulting in an MMPI prevalence of 0.1% (Coyer et al., 2021).

Some other international studies have reported MMPI within larger incidence studies, although MMPI-specific incidence cannot be calculated and often include only patients with a medical device in situ. Recent such studies have identified MMPI proportions of 15.3% from 98 medical device-related pressure injuries identified in 91/694 patients admitted to intensive care units across 30 Chinese hospitals (Dang et al., 2021), and 63.7% from 215 medical device-related pressure injuries recorded in 84/172 patients with a device in situ in a Turkish intensive care unit (Dalli et al., 2022). Similarly, a recent Australian point prevalence study reported an MMPI proportion of 42% from 101 device-related pressure injuries in 71/631 patients admitted to an intensive care unit with a device in situ (Coyer et al., 2022). Evidently, MMPI incidence has been largely reported in, or calculated from, Australian studies, and further international research is needed to provide global insight into the scope of MMPI incidence.

Based on our results, the incidence of MMPI in intensive care is around 70 times greater than that of non-intensive care patients, which is consistent with other emerging evidence demonstrating that the majority of MMPI occur within the intensive care setting, although these results are limited to data published in Australian studies. In the 18 Australian hospitals analysed between 2012 and 2014 by Coyer et al. (2017), and more recently between 2015 and 2019 (P. Fulbrook, J. Lovegrove, F. Coyer, unpublished), the proportions of MMPI out of all pressure injuries were significantly higher in intensive care versus non-intensive care patients (22% versus 2% and 11.6% versus 2%, respectively). Similarly, in another Australian study, 28% (50/179) of hospital-acquired pressure injuries were medical device-related, of which 20 were MMPI with the majority (n = 17) in intensive care (Barakat-Johnson et al., 2017). This is unsurprising given the much higher use of therapeutic and diagnostic devices in intensive care compared to general wards and emphasises the need for increased MMPI surveillance and pressure injury prevention practices in the intensive care setting. Given that virtually all MMPI reported in our study were associated with the presence of a medical device at the site of injury, our study provides evidence that a concerted effort is needed to reduce these injuries. The recently developed and updated international consensus document on device-related PI provides strategic guidance on the prevention of such injuries (Gefen et al., 2020, 2022).

Notably, in our study, the majority of intensive care MMPI were located on the mouth, tongue and lips and were associated with oral endotracheal tube-related devices (84.8%) and nasal/oral gastric tubes (5.3%), followed by the genitals associated with urinary catheters (7.0%). Time-to-pressure injury was also shortest for endotracheal tube-related devices and gastric tubes, suggesting that strategies to reduce MMPI in intensive care settings should focus on these devices, particularly oral endotracheal tubes. Our results are consistent with other studies that have indicated that endotracheal tubes, urinary catheters and nasogastric tubes are the devices primarily associated with MMPI (Barakat-Johnson et al., 2017; Coyer et al., 2014; Dalli et al., 2022). However, it is often unclear whether endotracheal tube-related MMPI are caused by the tube itself, the tapes used to tie it in place, or the various attachment devices that are used. Frequently, this level of detail was not recorded in our database. As such, more specific reporting and further research regarding the various endotracheal tube-related devices and MMPI are warranted to further hone preventative strategies. Furthermore, no anal MMPI were identified in our study, which may reflect the infrequent use of faecal tubes/systems or the possibility of underreporting. Some other studies have reported device-related pressure injury associated with 'urine or faecal' tubing (Arnold-Long et al., 2017) or faecal management systems (Cooper et al., 2015), but it was unclear whether these injuries were located anally, on the skin or on a mucous membrane. In our study setting, faecal management systems are used occasionally to manage faecal incontinence, mostly for intensive care patients that cannot be turned easily, such as those being treated with extracorporeal membrane oxygenation. Sometimes, patients are admitted to intensive care post-surgery with a faecal management system in situ.

Our study also sheds light on which devices are responsible for MMPI in non-intensive care patients. Of interest, seven MMPI associated with oral endotracheal tube-related devices were reported. Most of these were in clinical areas where patients may be intubated, such as the operating theatre or emergency department. However, some were also reported in ward areas where it would be unusual for patients to be intubated. Further investigation of these cases indicated that patients with these MMPI had previously had an endotracheal tube in place, and an assumption was made that the MMPI was related. This highlights the possibility of inaccurate pressure injury reporting, which has been noted in other studies (Barakat-Johnson et al., 2018; Crunden et al., 2022; Team et al., 2020). Other devices associated with MMPI in non-intensive care patients were mainly urinary catheters (51.4%), gastric tubes (20.8%) and nasal prongs (18.1%), indicating the most important devices to target preventative intervention.

All of the hospital-acquired MMPI in our study were associated with medical devices, with the exception of five. Four MMPI

did not have associated device data reported, while the other was caused by the patient's own skin. In this case, the MMPI was caused by the patient's external anatomy pressing up against the mucosal tissues of a vaginal prolapse. This is congruent with the current international clinical practice guideline for pressure injury prevention and treatment, which notes that MMPI are primarily caused by medical devices (EPUAP et al., 2019). However, it is not consistent with other definitions of MMPI, which have specified that an MMPI is found on a mucous membrane which has a history of medical device use at the site of the injury (Edsberg et al., 2016; Mucous Membrane Task Force, NPUAP, 2008). While the vast majority of MMPI are associated with device use, this may not always be the case, and future definitions should take this into consideration.

Skin pressure injury classification systems should not be used to stage MMPI due to the differences between the mucous membrane and skin tissue (Edsberg et al., 2016; EPUAP et al., 2019; Mucous Membrane Task Force, NPUAP, 2008). In this study, the majority of MMPI were initially reported correctly as MMPI, but a clinically significant proportion (16%) were incorrectly staged as skin pressure injuries. It is likely that the incorrect use of skin classification systems is not isolated to this study, as many studies that have examined device-related pressure injury occurrence have not identified or reported MMPI at all (Fulbrook et al., 2022). Within intensive care, MMPI was initially reported correctly in a large majority (89.5%), as opposed to a much lower proportion of correctly reported MMPI outside of intensive care (63.5%), which may reflect the increased rates of and familiarity with MMPI in the intensive care setting. Notably, most of those incorrectly reported were categorised as being Stage II pressure injuries (61%). Further education may be needed in this area to increase knowledge of MMPI and combat the incorrect use of skin classification systems for MMPI, especially regarding Stage II incorrect classification. However, sometimes it may be difficult to determine whether a pressure injury is predominantly mucosal when it occurs at the skin/mucous membrane border. Indeed, the pressure injuries incorrectly categorised as being Stage II were located on the genitals (36.1%), nose (27.8%), mouth (19.4%), lips (13.9%) and neck/tracheostomy site (2.8%), all of which are locations in which an MMPI may have bordered on the skin.

Alternatively, a classification system specific to oral MMPI has recently been developed and tested (Reaper et al., 2017), which may assist with staging of these injuries and consistent reporting, although there are no similar tools available for MMPI classification at other body sites. The Reaper Oral Mucosa Pressure Injury Scale (ROMPIS) categorises MMPI into three stages, ranging from Stage 1 with redness and demarcation of the lop/buccal mucosa without destruction of loss of tissue, ulceration or blisters, or non-blanchable erythema on the corners of the mouth, to Stage 3 with loss of mucosa and sub-mucosal tissue (Reaper et al., 2017). In reliability testing using photographs, the ROMPIS demonstrated 'fair' interrater reliability between 52 intensive care nurses, and between eight pressure wound management experts (Reaper et al., 2017). More recently, the ROMPIS MMPI staging descriptors were updated by an expert panel of intensive care nurses (Fitzgerald et al., 2022). In testing of the original and modified versions using images, interrater reliability between 72 nurses was fair for both, although better for the modified version (Fitzgerald et al., 2022). Nonetheless, this has provided a starting point for MMPI staging which requires further development and research. From a clinical perspective, however, there is potential for skin pressure injury staging to be confused with MMPI staging, if similar nomenclature is used. Additional insight may be gained from future investigations into the healing rates of MMPI and impacts and long-term effects for those afflicted. Coyer et al. (2014) found that out of eight MMPI identified in one study, three had healed and two had shrunk within seven days, suggesting a relatively fast healing rate. However, literature pertaining to MMPI healing rates and impacts is otherwise limited.

5 | LIMITATIONS

This study relates specifically to data collected in an acute tertiary hospital which has a strong focus on safety and quality, with a historical emphasis on wound prevention and management. Thus, our results may not be generalisable to other settings. It is likely that there were some data entry errors within the original clinical incident reports and pressure injury audit database. However, wherever possible, anomalies were investigated by review of patients' charts and the original incident report data. Furthermore, not all MMPI may have been reported via the clinical incident system, and not all those reported were necessarily identified, reviewed and documented in the pressure injury database by QuEST, and thus, some may have been missing from analysis. Also, in some cases, the date the MMPI was reported via the clinical incident system may not be an accurate reflection of when the MMPI first occurred, and QuEST follow-up and review may have been delayed in some cases. In a relatively large proportion of the sample, the device insertion date was not available for analyses, as this detail was not recorded in the patients' charts. In terms of time-to-MMPI, for three of the associated device types, only a small number were available for analysis. Device insertion time was based on the most recent insertion date. In some cases, this may have been a device replacement date. Furthermore, estimates of time-to-MMPI are crude, as they are based on whole day measures. Finally, it is important to acknowledge that our results are historical and may not reflect current rates of MMPI.

6 | IMPLICATIONS FOR PRACTICE AND RESEARCH

This study has provided important MMPI incidence data that will enable other health facilities to benchmark their own data. While, in the main, MMPI heal relatively quickly with little long-term impact on the patient, they represent a significant proportion of all hospital-acquired pressure injuries, especially within intensive care. Reducing

their incidence would in turn impact significantly on overall hospital- and intensive care-acquired pressure injury rates. Given that pressure injury rates are regarded as a measure of quality of care, this would represent an important clinical outcome. In terms of research, to our knowledge, this is the first study to rigorously analyse MMPI incidence and characteristics. However, further research is needed in other acute and different care settings globally before generalisations can be made.

7 | CONCLUSION

Overall, this study has provided MMPI incidence benchmarking data for acute hospitals overall, as well as non-intensive care and intensive care cohorts. While these data are derived from one Australian healthcare facility, broader, international MMPI incidence data are not yet available and further research is needed globally in this area. While the incidence of MMPI was low across the hospital setting, it represents a clinically significant issue that impacts patients, especially those in intensive care, where incidence is higher and the use of medical devices is greater. The appropriate use of preventative measures is critical to reduce the incidence of hospital-acquired pressure injury, and the results of this study may be used to inform targeted strategies to reduce MMPI. In particular, our results indicate that the devices most commonly associated with MMPI, which require prophylactic care, are endotracheal tube-related devices, urinary catheters and gastric tubes.

AUTHOR CONTRIBUTIONS

Study conception and design: Paul Fulbrook; acquisition, analysis and interpretation of data, manuscript drafting, and manuscript finalisation and approval for submission: all authors; critical revisions for important intellectual content: Paul Fulbrook, Josephine Lovegrove.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY STATEMENT

Data available on reasonable request from the authors.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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