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Creation of a National Chronic Wound Registry—Challenges and Opportunities

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ABSTRACT

Chronic wounds pose an increasing burden on the healthcare system and data on wound outcomes and are needed to evaluate and address disparities and reform healthcare policies. In Singapore, data on chronic wounds are fragmented and to address this, we established a Chronic Wounds Registry (CWR) to collect harmonised data on chronic wounds and their outcomes over 6 months. This is a multi-centre prospective cohort study from Nov 2019 to Nov 2021. Patients with chronic wounds were enrolled at multi-speciality acute care hospitals and data were prospectively collected on baseline characteristics, including subject demographics, clinical data, wound images, interventions/treatment, cost burden and patient reported health-related quality of life (HRQOL). Patients were followed up for 6 months and wound outcomes recorded at Month 1, Month 3 and Month 6 time points. Despite the onset of COVID pandemic, a total of 812 patients were recruited in our study. Mean age was 63.5 ± 11.6 years with 66% men and 59% of Chinese ethnicity. Twenty percent of all the wounds were recurrent and patients with venous leg ulcers (VLU) (32%) had the highest recurrence. At 6 months, 225 (46%) of the neuro-ischemic ulcers (NIU), 152 (60%) of the VLUs and 29 (46%) of the pressure injuries (PI) had healed. Major (5%) amputations were highest in patients with NIUs. All-cause mortality was highest (30%) and HRQOL was lowest for patients with PIs (−0.18). Development of a national wound registry is both feasible and essential to consolidate key data elements on chronic wounds. The CWR in its current state captured the local epidemiology, patient journey in acute care hospitals, which will benefit in healthcare policymaking and harmonise care across different levels of healthcare system. The next phase of the CWR aims to track patients in all settings and collect data on the entire patient journey following an episode of wounding.

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Summary

- Chronic wounds pose a large and often neglected challenge to Singapore's healthcare system. Understanding all aspects of the patient's journey is important for optimising treatment and improving healthcare service delivery.
- Multi-sectoral efforts led to the development of the Chronic Wound Registry (CWR), which is a comprehensive real-world data repository on chronic wounds that allows for evidence-based decision making and enables cost effectiveness assessment.
- The CWR allows for real-time tracking of wound outcomes, which forms the basis to study future interventions at a low cost. The study has shown that these data points can be collected in a routine patient and wound assessment visit.

1 | Introduction

Wounds are defined as barrier defects in the skin and the duration of wound healing varies across the literature from 1 to 3 months [1, 2]. Chronic wounds conventionally include neuroischemic foot ulcers (NIU) (including diabetic foot ulcers (DFU) and ischemic ulcer relating to peripheral arterial disease), venous leg ulcers (VLU) and pressure injuries (PI). As a result of demographic changes and increasing frequency of chronic diseases, the incidence of chronic wounds has tripled over the last decade in Singapore and the sharpest rise is seen in patients aged above 80 years [3]. With 1 in 4 citizens projected to be above age 65 by 2030, Singapore is particularly susceptible to the 'silent epidemic' of chronic wounds [4]. Interestingly, Singapore also has one of the highest rates of lower limb amputation rates globally, with around four DFU-related amputations occurring daily, which increases the urgent need for improvement in prevention and management strategies of chronic wounds [5]. The economic burden of chronic wounds has become increasingly evident in developed nations with UK and Australia spending about 3% and 2% of their total healthcare budget on management of chronic wounds, respectively [6, 7]. In the Scandinavian countries, the associated costs account for 2%–4% of the total healthcare expenses [8]. Graves et al. estimated a total annual cost of illness of $350 million SGD on chronic wounds, which is 3.6% of Singapore's annual healthcare budget [9].

There are increasing efforts to improve quality of care and outcomes through national reporting systems/registries, and the US Wound Registry illustrates relevance of a national Chronic Wound Registry (CWR), providing a real-world example of practical significance [10–12]. In Singapore, clinical data exist as isolated pockets within site-specific databases, lacking a harmonised and consolidated source of data on wounds at the national level. The creation of a national data repository that includes Ministry of Health derived data will allow for wound surveillance, quality of care assessment, refining clinical practice and changes to policy making. Moreover, the multi-ethnic composition of Singapore's local population provides a unique opportunity to study the differences in the three major ethnic groups in Asia, that is, the Chinese, Malay and Indian subpopulation. To address this need, we established the CWR with two objectives: (1) establish major acute care hospitals as stakeholders in development and design of a future National Wound Registry for determining value-based wound care strategies in Singapore and benchmarking Singapore internationally; and (2) Longitudinal tracking of wound outcomes for influencing current clinical practices and informing opportunities for patients with wounds. In this article, we describe the establishment, overview of its contents and results as of Dec 2021. Additional challenges of undertaking this study at the same time as the global pandemic caused by COVID made it impossible to complete a number of specific projects that were planned as part of this Nationwide collaborative initiative.

2 | Materials and Methods

2.1 | Setting

Patient recruitment occurred at three multi-specialty, acute care hospitals: (i) National University Hospital (NUH); (ii) Tan Tock Seng Hospital (TTSH); and (iii) Singapore General Hospital (SGH), with each representing one of the three major local healthcare clusters in the country as its flagship hospital. The clusters are (i) National University Health System; (ii) National Healthcare Group (NHG); and (iii) SingHealth system differentiated geographically as 'Western', 'Central' and 'Eastern', respectively. Each healthcare cluster is affiliated with primary and community care centres, providing a full complement of healthcare services. NUH is a 1200 bed acute care centre with over 8000 staff, and part of the NUHS cluster which has a catchment population of 1.1 million [13, 14]. TTSH, with 1600 beds, is the anchor hospital of the NHG healthcare cluster (catchment population: 1.4 million residents) [15]. SGH is an 1800 bed acute hospital, and part of the SingHealth cluster with a 1.4 million resident catchment population [16]. Prior to the commencement of the study, there was no integrated, standardised wound data system implemented across all three individual healthcare clusters. Each centre relies upon its site-specific electronic medical records (eMR) systems and/or Wound Specific Databases.

Prospective data collection involved longitudinal follow-up of patients at the acute care institutions for up to 6 months after initial enrolment (Table S1). The following patient data were systematically collected by the clinical research coordinators stationed at the three hospitals from Nov 2019 to Nov 2021:

- Epidemiological and clinical characteristics.
- Wound characteristics and wound images.
- Wound management: Including investigations and treatment details such as cleansing solutions, dressings, biological adjuncts, devices/used aids and surgical interventions.
- Wound-related healthcare utilisation: Including healthcare visits (primary care, specialist care, hospital admissions, nursing visits and hospital outpatient visits), costs associated with individual visits and patient reported health-related quality of life (HRQOL).
- Clinical outcomes: Wound healed, wound ongoing, recurrence, major/minor amputation, death. Development of

clinical wound infection and complete wound healing was defined based on any eMR documentation of resolution of the wound.

For patients with multiple ulcers, an index ulcer (i.e., the largest ulcer) was identified during the first clinic visit, which will be monitored during subsequent visits. During each clinic visit, wound measurements were recorded by a trained specialised wound nurse or podiatrist. A ruler was used to measure the length (defined as the longest axis) and width (defined as the longest axis perpendicular to the length) of the wound. The area was calculated by multiplying length and width. The ruler-based measurement was adopted despite recognising its limitations with accuracy and reproducibility as this was the only feasible option for our study at the time. Infection in wounds was defined on clinical grounds including the presence of purulent or malodorous discharge, peri-wound tenderness and/or erythema.

2.2 | Identification of Patients and Follow-Up

Eligible patients were either in-patients or attending outpatient wound clinic at one of the three acute care centres identified using the inclusion criteria (below) at an initial screening assessment.

2.2.1 | Inclusion Criteria

Patients were (1) adults who were able to provide consent themselves or by a legally authorised representative, and (2) a clinical primary/secondary diagnosis of NIU, VLU, or PI or diagnosed with PI during in-patient stay (based on the pre-defined list of diagnosis codes, TOSP [Table of Surgeries Procedures] or Investigations codes, and/or billing charge/service code of investigations which are deemed proxy of such diagnoses [Table S2]).

2.2.2 | Exclusion Criteria

Prisoners and other patients deemed as being from 'vulnerable populations' were excluded. Further, patients who had concomitant other diseases, comorbidities or other conditions that prevented follow-up of the patient by a study team member were excluded.

2.2.3 | Follow-Up of Patients

Follow-up of patients occurred at three timepoints: discharge from the service, Month 1, Month 3 and Month 6 calculated from the date of enrolment. Follow-up was conducted at the clinic (if the patient was still receiving treatment or re-admitted to the site), or via phone call by the study coordinator or a delegated study team member. Information collected during follow-ups included wound outcome (healing, recurrence, unhealed/ongoing, major amputation, minor amputation), patient journey (step down/discharge location), wound characteristics, healthcare cost data and quality of life assessment.

2.3 | Study Variables and Data Collection

Study coordinators used clinical research forms (CRFs) for data collection. The variables in the CRFs were finalised and standardised by a multidisciplinary team consisting of vascular surgeons, wound care nurses, podiatrists, and a health economist. The CRFs included both multiple-choice and free-text options. Data in the CRFs were later transcribed into the RedCAP database manually by trained study coordinators. Data extraction was conducted through various means: epidemiological and clinical data were primarily sourced from patients' electronic medical records (eMR), while cost data were retrieved retrospectively from the eMR and the hospital claims department.

Pain was scored using a Numerical Rating Scale (NRS), where patients rate their pain on a scale from 0 to 10. A score of 0 indicates '*no pain*', while a score of 10 represents the '*worst possible pain*'. Activities of Daily Living (ADL) were measured on a 3-point scale: (1) Independent/Semi-Independent—Able to perform light to normal activities without significant restrictions; (2) Assisted/Wheelchair-Bound—In a chair or bed for more than 50% of the time, but not bedridden; and (3) Bedbound—Completely disabled and unable to perform self-care. HRQOL was assessed using the standardised EuroQol 5-Dimensional (EQ-5D) questionnaire. The study coordinators administered the validated EQ-5D questionnaires at specific time points to collect quality of life data.

Image-taking of wounds occurred by recording study code and date onto a paper ruler, which was aligned with the wound location on the patient. Using an approved camera, a colour image of the wound and ruler (in a perpendicular angle) was taken, with the wound image encompassing approximately 50% of the photo frame. An EQ-5D questionnaire was administered during enrolment.

2.4 | Data Quality Assurance and Storage

Data from paper CRFs were manually transcribed into the RedCAP database. Personnel from Skin Research Institute of Singapore (SRIS) conducted regular site visits and audits to ensure data accuracy and completeness. Registry data were cross-checked against the CRFs and patients' eMR, with any discrepancies identified and corrected. Data completeness was ensured at two levels: first, during data collection, coordinators followed up with patients who missed scheduled study visits; second, data were transferred to the registry database in batches, where the oversight committee would review for completeness and request additional information if any data were missing.

Hardcopy documents were stored securely at the sites and electronic data was stored on an encrypted, secured and password protected hard disk in the hospitals. Individual datasets were de-identified, harmonised at source and onloaded to CWR database housed at SRIS. The database is securely maintained, password protected, and is behind the SRIS firewall with limited access granted only to study-specific personnel.

3 | Statistical Analysis

We report the baseline characteristics of our wound registry cohort. Descriptive statistics are reported with mean and standard deviation (SD) for continuous variables and categorical variables are reported with frequencies and proportion.

4 | Results

A total of 812 patients were recruited in the Wound Registry from Nov 2019 to May 2021, out of which 494 patients had NIUs, 255 had VLUs and 63 patients had PIs. Interpretation of data on PIs needs to be undertaken with caution due to the small number of patients included in the study. The mean age of patients was 63.5 ± 11.6 years and 66% of them were males. Chinese (59%) was the most common ethnicity followed by Malays (19%) and Indians (19%). Being overweight or obese was more common among those with NIU or VLU than those with PIs. Majority of the study population had hypertension (77%), diabetes (76%) and dyslipidemia (80%). Most patients with NIU (66%) and VLU (84%) were able to perform activities of daily living independently, while approximately one-third of patients with PI were bedbound. Baseline patients' characteristics are presented in Table 1.

4.1 | Wound Characteristics and Outcomes

Twenty percent of all the wounds were recorded as having a history of recurrence and patients with VLUs (32%) had higher proportion of recurrence followed by NIU (18%) and PI (11%). Most common site for NIUs was toes (47%) and PIs was sacrum (44%). At the time of enrolment, the mean duration of wounds was 6 months for NIUs, 9 months for PIs and more than a year for VLUs. NIUs were the smallest in size with a mean size of 9 cm^2 followed by VLUs (18 cm^2) and PIs (21 cm^2). Less than 20% of all wounds were clinically infected at the onset of the study, with NIUs being the most common subtype to be infected (20%). Presence of pain as a symptom was seen in one-fourth of all the patients with VLUs being the most common subtype affected (45%). Malodour as assessed by the clinician was not a common feature (4%) in all wounds. Granulation tissue was seen in the majority of NIUs (77%) and VLUs (83%) while it was seen in only 23% of PIs. Maceration was the most common appearance of peri-wound skin in NIU (36%) and healthy skin was most common in VLUs (38%) and PI (30%). Exudate level was slight in majority of the wounds with NIUs commonly having a haemoserous type of exudate (54%) and VLUs and PIs mostly having a serous type of exudate. Of the 812 patients, about 406 (50%) healed within 6 months, with VLUs (60%) having the highest rates of healing followed by PI (46%) and NIU (46%). Major amputations (5%) were highest in patients with NIUs. All-cause mortality was highest for patients with PI (30%). Wound characteristics and outcomes of all patients are presented in Tables 2 and 3, respectively.

5 | Discussion

Meeting the growing interest in value-based healthcare requires capturing all interactions in a patient's journey across all tiers of the healthcare system. As an initial step towards building a unique data repository on chronic wounds in Singapore, a multi-centre initiative was launched by three major acute care hospitals in collaboration with SRIS. This initiative aimed to create a comprehensive database that captures various aspects of a patient's journey, including wound outcomes at the end of the study. In this paper, we discuss the challenges associated with setting up such a registry and provide an overview of the registry data.

Chronic wounds are managed by multiple medical specialities and professional groups such as nurses and podiatrists, highlighting the complexity of providing wound care and the need for an evidence-based multi-disciplinary treatment approach based on real-world data. Registries for chronic wounds are scarce, with only a few existing in Sweden, the United States, Wales and Finland [17–20]. Additionally, there are a few publications mentioning plans for such registries in Australia [21]. In Singapore, wound-specific data collection is fragmented, lacking a standardised clinical outcome tracking system. The primary challenge in setting up the wound registry was harmonising data across different healthcare systems, requiring multiple stakeholders agreeing upon core data elements and data formats, which was a time-consuming exercise. This was in a setting where there was no history of the different providers working in a cooperative manner on a national scale.

Data collection for our registry mirrored that of a prospective clinical study where we collected relevant information in a pre-defined manner. Clinical information was derived from eMR, healthcare costs and utilisation data were collected from administrative datasets and quality of life data were collected through patient-administered questionnaires. This multi-source data collection methodology, though expensive, provides us with a rich and comprehensive patient-centric pool of data. Various subsets of data from this registry have already been used to explore wound epidemiology and the cost of illness [9, 22, 23].

Direct comparisons between different wound registries are difficult to make, but one distinguishing factor is the source of the clinical data. For instance, while the Swedish registry focusses on data from primary care, the Singapore registry was designed to collect comprehensive information from primary to tertiary care. However, obtaining data from primary care has been challenging due to the lack of integration between tertiary and primary care eMRs. Furthermore, there is no standardised system to track wound outcomes longitudinally in Singapore, and tracking of wound outcomes through the CWR is one of the strengths of this database. In this regard, Singapore CWR is similar to Finland wound registry, which also monitors wounds over time. This longitudinal tracking enables the randomization of patients for interventions, with the data flowing back into the registry. This also means the intervention trails are 'real world' and generalisable; low cost to conduct; and the data collected allows for the assessment of cost-effectiveness outcomes.

The mean age of our study population was 63.5 years with 63% being males, similar to what has been reported in other local studies [24]. There is enough evidence to suggest correlation

TABLE 1 | Baseline features of all patients with chronic wounds.

	All, *n* = 812	**NIU, *n* = 494**	**VLU, *n* = 255**	**PI, *n* = 63**
Gender, *n* (%)				
Female	279 (34.36)	143 (28.90)	108 (42.35)	28 (44.44)
Male	533 (65.64)	351 (71.10)	147 (57.65)	35 (55.56)
Age, mean (SD), years	63.5 ± 11.6	62.1 ± 10.5	65.2 ± 11.6	67.3 ± 16.9
Ethnicity, *n* (%)				
Chinese	475 (58.50)	281 (56.90)	152 (59.61)	42 (66.67)
Malay	154 (18.97)	100 (20.20)	41 (16.08)	13 (20.63)
Indian	154 (18.97)	98 (19.80)	51 (20.00)	5 (7.94)
Others	29 (3.57)	15 (3.04)	11 (4.31)	3 (4.76)
BMI, mean (SD)	27.6 ± 7.0	27.1 ± 6.4	29.6 ± 7.3	23.6 ± 8.2
BMI, *n* (%)				
Underweight (≤ 18.5)	41 (5.41)	21 (4.45)	6 (2.61)	14 (25.00)
Normal weight (18.5–24.9)	240 (31.66)	161 (34.11)	54 (23.48)	25 (44.64)
Overweight (25–29.9)	247 (32.59)	167 (35.38)	71 (30.87)	9 (16.07)
Obesity (≥ 30)	230 (30.34)	123 (26.06)	99 (43.04)	8 (14.29)
Smoking status, *n* (%)				
Current	119 (14.66)	83 (16.80)	30 (11.76)	6 (9.52)
Ex-smoker	67 (8.25)	41 (8.30)	24 (9.41)	2 (3.17)
Comorbidities, *n* (%)				
Hypertension	623 (76.72)	431 (87.25)	155 (60.78)	37 (58.73)
Diabetes	615 (75.74)	481 (97.37)	107 (41.96)	27 (42.86)
Duration, mean (SD), years	13.0 ± 8.9	13.6 ± 9.1	10.7 ± 7.3	10.1 ± 8.3
HbA1C mean (SD), %	8.1% ± 2.1%	8.3% ± 2.1%	7.5% ± 1.9%	7.5% ± 2.0%
Patients on insulin	329 (53.50)	283 (58.90)	27 (25.23)	19 (70.37)
Dyslipidemia	649 (79.93)	457 (92.50)	160 (62.75)	32 (50.79)
Coronary artery disease	212 (26.11)	170 (34.40)	32 (12.55)	10 (15.87)
Chronic heart failure	102 (12.56)	79 (15.99)	19 (7.45)	4 (6.35)
PAD	357 (43.97)	316 (63.97)	37 (14.51)	4 (6.35)
ADL status				
Independent and semi-independent	536 (66.00)	307 (62.14)	214 (83.92)	15 (23.80)
Assisted or wheelchair bound	260 (3.20)	186 (37.65)	41 (16.07)	33 (52.38)
Bedbound	16 (1.97)	1 (0.20)	0	15 (23.80)
HRQOL, mean (SD)	0.476 (0.416)	0.497 (0.397)	0.566 (0.348)	−0.176 (0.335)

Note: All categorical variables are expressed as *n* (%) and all continuous variables are expressed as mean ± standard deviation.
Abbreviations: ADL, assisted daily living; BMI, body mass index; HRQOL, health-related quality of life; NIU, neuro-ischemic ulcer; PAD, peripheral arterial disease; PI, pressure injury; VLU, venous leg ulcer.

between obesity and impaired wound healing and in a review done by Barber et al., almost 87.2% of the patients with chronic wounds were either overweight or obese [25]. The mean BMI in our study was 27.1 kg/m^2 with 63% of the patients having a BMI over 23 kg/m^2, compared to 40% of Singapore's general population [26]. Notably, 25% of the patients with PI's were underweight, highlighting the importance of routine nutritional assessment as part of wound care and management. Multiple comorbidities exist in patients with chronic wounds and in a study by Goh et al., patients with chronic wounds were found to have

TABLE 2 | Baseline wound characteristics of all patients with chronic wounds.

	All, $n = 812$	NIU, $n = 494$	VLU, $n = 255$	PI, $n = 63$
Prior wound history, n (%)	175 (21.55)	87 (17.60)	81 (31.76)	7 (11.11)
Duration, mean (SD), years	0.86 ± 2.3	0.66 ± 1.4	1.25 ± 3.5	0.92 ± 2.7
Wound site, n (%)		Toes—231 (46.80) Sole—106 (21.50) Dorsum—47 (9.51) Lateral—41 (8.30) Heel—39 (7.89) Medial—25 (5.06)	Left LL—138 (54.12) Right LL—117 (45.88)	Sacrum—28 (44.44) Heel—12 (19.05) Buttocks—11 (17.46) Back—3 (4.76) Trochanter—2 (3.17) Elbow—1 (1.59) Others—6 (9.52)
Wound size, mean (SD), cm^2	13.0 ± 35.6	9.29 ± 17.5	18.0 ± 54.7	21.1 ± 38.5
Wound bed appearance, n (%)				
Granulation	609 (75.00)	381 (77.13)	213 (83.53)	15 (23.81)
Eschar	73 (8.99)	61 (12.35)	7 (2.75)	5 (7.94)
Epithelialization	73 (8.99)	20 (4.05)	45 (17.65)	8 (12.70)
Slough	312 (38.42)	195 (39.47)	103 (40.39)	14 (22.22)
Others	126 (15.52)	94 (19.03)	17 (6.67)	15 (23.81)
Malodour, n (%)	33 (4.06)	15 (3.04)	13 (5.10)	5 (7.94)
Pain, n (%)	203 (25.00)	82 (16.60)	116 (45.49)	5 (7.94)
Pain score, mean (SD)	5.0 ± 2.5	4.2 ± 2.2	5.6 ± 2.6	2.8 ± 0.8
Presence of Exudate, n (%)	557 (68.60)	360 (72.87)	170 (66.67)	27 (42.86)
Type of exudate, n (%)				
Serous	296 (53.14)	153 (42.50)	130 (76.47)	13 (48.15)
Haemoserous	241 (43.27)	196 (54.44)	39 (22.94)	6 (22.22)
Purulent	21 (3.77)	14 (3.89)	4 (2.35)	3 (11.11)
Others	4 (0.72)	4 (1.11)	0 (0)	0 (0)
Amount of exudate, n (%)				
Slight	336 (60.32)	217 (60.28)	94 (55.29)	25 (92.59)
Moderate	175 (31.42)	117 (32.50)	57 (33.53)	1 (3.70)
Heavy	40 (7.18)	21 (5.83)	19 (11.18)	0 (0)
Peri-wound appearance, n (%)				
Healthy	275 (33.87)	158 (31.98)	98 (38.43)	19 (30.16)
Maceration	239 (29.43)	179 (36.23)	53 (20.78)	7 (11.11)
Excoriation	48 (5.91)	37 (7.49)	10 (3.92)	1 (1.59)
Erythematous	73 (8.99)	32 (6.48)	36 (14.12)	5 (7.94)
Oedematous	31 (3.82)	17 (3.44)	14 (5.49)	0 (0)
Others	235 (28.94)	125 (25.30)	81 (31.76)	29 (46.03)
Wound infection, n (%)	131 (16.13)	103 (20.85)	20 (7.84)	8 (12.70)

Note: All categorical variables are expressed as n (%) and all continuous variables are expressed as mean ± standard deviation.
Abbreviations: NIU, neuro-ischemic ulcer; PI, pressure injury; VLU, venous leg ulcer.

TABLE 3 | Wound outcomes at the end of 6 months.

Outcome, n (%)	All, $n = 811$[a]	NIU, $n = 493$[a]	VLU, $n = 255$	PI, $n = 63$
Healed	406 (50.00)	225 (45.55)	152 (59.61)	29 (46.03)
On-going	336 (41.38)	222 (44.94)	101 (39.61)	13 (20.63)
Major amputation	24 (2.96)	22 (4.45)	0 (0)	2 (3.17)
Deceased	45 (5.54)	24 (4.85)	2 (0.78)	19 (30.15)

Note: All categorical variables are expressed as n (%).
Abbreviations: NIU, neuro-ischemic ulcer; PI, pressure injury; VLU, venous leg ulcer.
[a]Due to missing data, the total does not align with the overall number of wounds.

a mean Charlson Comorbidity Index (CCI) score of 6 [3]. While we did not calculate the CCI score, over two-thirds of our patient cohort had either of the three co-morbidities, hypertension, hypertriglyceridemia and hyperglycaemia (3H's). Although, the 3H's have not been proven as a risk factor for chronic wounds, our CWR database enables identification of additional potential risk factors for chronic wounds.

Accurate wound assessment is critical for evaluating wound progress and assessing treatment efficacy in wound management. Evaluation of wound bed, margin and peri-wound appearance are important parameters in wound assessment. However, most of these wound assessments are subjective and may not be accurate or reproducible [27]. Comparable to our results, Yosip et al. reported a high proportion of granulation tissue in chronic wounds though their study showed a higher percentage of epithelization (48%) compared with ours (7.9%) [28]. This raise concerns over the reliability and consistency of such assessments. Emphasising the need for consistent training and the use of devices to quantify factors deemed to be most relevant. The presence of exudate was seen in 68% of the wounds, with only 7% heavily exuding, despite this information many commercial organisations are developing dressings, which address heavily exudating wounds. Wound registries can be a valuable resource for industries as they provide immense data on disease-specific clinical needs, allow for monitoring treatment response and efficacy of the product. Such information will allow for developments focused on clinical need rather than external factors.

The three subclasses of wounds have distinct clinical pathways and end outcomes, understanding of which is crucial for allocation of healthcare resources towards each category. In terms of outcomes, VLUs had a high recurrence (32%) with no amputations and very low mortality risk. The high rate of recurrence in VLUs points towards the challenge of maintaining these patients in an ulcer-free state. The NIU subclass was associated with lower extremity amputations and major amputation rate of 5% which is comparable to a previous study by Lo et al. [29] PIs were associated with higher mortality, and this supports the literature where chronic wounds are stated as markers of frailty [30]. PI patients also had the lowest patient reported quality of life as compared to patients with NIU and VLUs. This also raises the issue of defining success in wound care; wound healing being considered as a success and amputation is viewed as a failure. However, success should be defined by outcomes that patients find acceptable and appropriate. Patient reported experience measures (PREMS) and outcome measures (PROMS) should be developed and included in future iterations of the CWR to better capture these perspectives.

We recognise several limitations in our study. The major one being its focus on recruiting patients at acute care centres, chronic wound recording at the primary care level would have enabled accurate and comprehensive 'baseline' wound characteristics to be collected, providing a better overview of wound development and progression. Expanding the patient population to include primary care centres is a future challenge that we foresee. Another limitation is that only the index wound per patient was recorded, despite the possibility of multiple wounds at the time of recruitment. Additionally, patients with more than one wound with mixed aetiology were not identified. These limitations reduce our ability to fully understand the complexity of wound healing dynamics, associated treatment costs, and the impact on patients' quality of life. In the future, the registry should aim to collect data on all wounds present at recruitment. Another challenge that we faced was patient confidentiality. Patients with PI's were not recruited at two of the three acute centres, excluding potentially the most vulnerable patients who were unable to provide informed consent. Thus, while Lo et al.'s 5-year institutional population health review found that PI patients constituted the largest cohort of chronic wound patients in Singapore, the majority of patients from our study had NIUs [29]. This might result in underreporting of the true burden of PIs. Another limitation of our study was incomplete assessments at follow-up visits, which was also due to the COVID pandemic, which made conducting research extremely challenging as services were being re-established. Conducting and completing the study required considerable support from clinicians, patients, managers and approvals at facility and government levels. Lastly, this is a descriptive presentation of results from our pilot registry and does not allow for any confirmed risk prediction or causality.

6 | Conclusion

In an increasingly competitive healthcare market, insights from large datasets are being used to future proof health services and systems. Although considerable information is routinely collected on patients with wounds, it is currently uncoordinated and lacks meaningful consolidation into a comprehensive wound record. Despite these challenges, we successfully established a registry that collects real-world data to generate evidence and answer research questions on wound epidemiology, treatment variations and outcomes, assessing their effectiveness. This study has demonstrated the feasibility of collecting hospital-based information on chronic wounds in a standardised manner.

Demographics and disease patterns change over time and various factors present in our population may influence the progression of their wounds for, for example, hypertension, dyslipidemia and diabetes mellitus. Understanding these factors are key drivers for improving clinical practice and outcomes for patients with chronic wounds. Outcome tracking in patients with chronic wounds needs further exploration as wound recurrence may become an increasingly significant challenge as services develop and mature. We acknowledge the major weakness of our study: lack of data capture beyond hospital settings, as currently there is no system to coordinate and collect information from other care provisions offered to these patients in Singapore. However, data collection and collation from acute care hospitals marks the beginning of a journey to build a comprehensive data set of care provided and outcomes achieved at a national level.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The research data are not publicly available.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.