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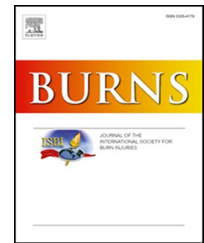
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Development of an electronic burns register: Digitisation of routinely collected hospital data for global burns surveillance

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ABSTRACT

Introduction: Burn registers provide important data that can track injury trends and evaluate services. Burn registers are concentrated in high-income countries, but most burn injuries occur in low-and-middle-income countries where surveillance data are limited. Injury surveillance guidance recommends utilisation of existing routinely collected data where data quality is adequate, but there is a lack of guidance on how to achieve this. Our aim was to develop a rigorous and reproducible method to establish an electronic burn

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Register
Routinely collected data
India

register from existing routinely collected data that can be implemented in low resource settings.

Methods: Data quality of handwritten routinely collected records (register books) from a tertiary government hospital burn unit in Mysore, India was assessed prior to digitisation. Process mapping was conducted for burn patient presentations. Register and casualty records were compared to assess the case ascertainment rate. Register books from February 2016 to February 2022 were scanned and anonymised. Scans were quality checked and stored securely. An online data entry form was developed. All data underwent double verification.

Results: Process mapping suggested data were reliable, and case ascertainment was 95%. 1930 presentations were recorded in the registers, representing 0.84% of hospital all-cause admissions. 388 pages were scanned with 4.4% requiring rescanning due to quality problems. Two-step verification estimated there to be errors remaining in 0.06% of fields following data entry.

Conclusion: We have described, using the example of a newly established electronic register in India, methods to assess the suitability and reliability of existing routinely collected data for surveillance purposes, to digitise handwritten data, and to quantify error during the digitisation process. The methods are likely to be of particular interest to burn units in countries with no active national burns register. We strongly recommend mobilisation of resources for digitisation of existing high quality routinely collected data as an important step towards developing burn surveillance systems in low resource settings.

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1. Introduction

Burn registers collect data about patients who present to hospital with a burn injury. They are an essential element of surveillance, providing data for purposes such as tracking of emerging injury trends, service improvement, care quality assessment, and evaluation of interventions [1]. This can reduce the likelihood of burn injuries occurring, as well as improving post-injury care and rehabilitation (i.e. primary, secondary, and tertiary prevention). Large scale country-wide and inter-country burn registers are primarily found in high-income countries (HICs) [2]. An exception is the World Health Organisation's Global Burn Register (WHO GBR) – a burn register established in 2017 that collects variables tailored towards primary prevention and is free to participate [3]. Of the 37 healthcare facilities that submit data to the WHO GBR, 34 (92%) are from low- and middle-income countries (LMICs) [4]. There have also been several pilot burn registers in countries including India, Pakistan, Bangladesh, and Kenya though these do not appear to have been scaled up to a continuous register [5–7]. The uptake of the WHO GBR, as well as the proliferation of pilot burn registers, suggests there is an increasing appetite in the global burns community for this type of data, but that long term sustainability may be an issue, particularly for LMICs. International guidance exists for establishing and maintaining other types of clinical registers, but there is none specific to burn injuries [8].

Arguably burn registers are needed most in LMICs. The Global Burden of Disease study estimates that approximately 9 million people annually sustain a burn injury requiring medical treatment, with 120,000 deaths [9]. More than 80% of burn injuries occur in LMICs, a quarter of which are in India. However, the majority of LMICs have poor surveillance data meaning that injury rates may be underestimated and data

are unreliable [9–11]. Countries without a national injury surveillance system are encouraged to establish their own (e.g. burn register) at whatever level is feasible (local, regional, or national) [8,12].

Establishing and maintaining a clinical register is costly [13,14]. It is essential that the variables collected by the register are useful, and that the resultant data is reliable, to prevent wasteful use of limited resources. Variables should provide data that is valuable at both local and national levels to ensure that it can be fed back into health systems to achieve improvements [12]. Published burn register studies tend to be from large country-wide or international registers, but a register is defined as any physical or electronic collection of pre-specified and systematically recorded details [2,15]. They can be based in a single centre. Data that is rigorously collected from a single centre can still influence interventions and policy at a national level [16].

The WHO's Injury Surveillance Guidelines were published over 20 years ago and remain relevant, particularly for countries with no active injury surveillance system [12,17]. The Guidelines recommend appraisal of existing data sources prior to establishing new data collection processes. Burn units may already collect data that could form a register, though the custodian of these data may not recognise this. An example is a handwritten admission book that collates simple variables such as patient name, hospital number, address, injury details, and discharge date. This type of routinely collected data is typically used for local administrative purposes, but may be of wider utility were it in a more readily analysable format [12]. Utilisation of existing handwritten data could be particularly useful for burn units wishing to establish a more detailed electronic register. It can provide information on which variables have been routinely collected using current resources, which of these should continue to be collected, and highlight areas that require new variables to be

collected to provide additional detail. The existing data may provide important epidemiological insights that could justify scaling up of the register, as well as for surveillance. Digital data is easier to analyse and share than handwritten data, but the conversion process requires resources. Data quality should be assessed prior to committing to digitisation. High quality data is required to ensure that correct conclusions are drawn from it. It is well-recognised that register data is of highly variable quality, and this can have negative consequences for patients [18,19]. Errors can occur in register data at multiple points, including failure to ascertain all cases of interest, incorrect documentation in case notes by the original clinician, and incomplete or incorrect information entered into the register database fields [20]. There is a gap in international guidance on how to appraise the quality of existing routinely collected burns data, how to employ modern digital methods to develop a reliable burn register from such data, and how to quantify the error in burn register data.

Our aim was to develop a rigorous and reproducible method to establish an electronic burn register from existing routinely collected data that can be implemented in low resource settings. We illustrate this by sharing the experience of digitising a handwritten register from a tertiary government hospital burn unit in south India.

2. Methods

2.1. Ethical review

Ethical approval for the South Asia Self-Harm Initiative register workstreams has been granted by the University of Manchester University Research Ethics Committee (2019–6534–11297, 2021–10049–17533, 2022–10049–22753), JSS Academy of Higher Education and Research Institutional Ethical Committee (JSSMC/IEC/2903/09NCT/2018–19), and Mysore Medical College and Research Institute Ethical Committee (MMC EC 18/19, MMC EC 86/21). This includes approval to utilise routinely collected hospital data for research purposes without additional patient consent. Stakeholder consultation completed during the process mapping exercise were conducted with informed consent.

2.2. Study objectives

1. Assess the suitability of a handwritten pre-specified and systematically recorded routinely collected data source (burn register) for digitisation
2. Establish a process for digitisation that enables all register data to be readily analysed
3. Quantify the level of error during the digitisation process

The processes followed to achieve the study objectives are shown in Fig. 1. No reporting guideline for studies of this nature were found on the Enhancing the Quality and Transparency of Health Research Network website [21].

2.3. Setting

Krishna Rajendra (KR) Hospital, Mysuru, India is a large government teaching hospital with approximately 1800 beds,

all major specialities, and an attached medical college. One of the authors, MKa, established a register in 2001 of admissions to the burn unit of KR Hospital. Pre-specified data fields are completed prospectively in handwritten A3 ledgers and as such can be considered a register. Completed books are sent to the hospital records department for storage. The register was used for hospital audit purposes only until the present study. The data were known to be appropriate for burns surveillance but had not been used for this purpose due to the difficulty in analysing handwritten data.

2.4. Objective 1. Assess the suitability of a handwritten burn register for digitisation

Data quality was assessed firstly by reviewing a sample of register books, then reviewing data collection processes using process mapping, and finally by quantitatively assessing data capture (Fig. 1). A clinician researcher visited KR hospital 10 times between July 2019 and February 2020. A sample of register books were requested from the medical records department to assess whether they could be retrieved, which fields were included in the register, if the fields were consistent within and between register books, and the amount of missing data. Process mapping was then used to understand how patients with a burn injury obtain medical care at the hospital. Particular reference was made to who has their data included in the burn register, and which patient groups are likely to be missed. This was completed as part of a wider process mapping exercise to understand potential sources of selection bias in register data. Detailed description of the method has been published previously [22]. In summary, observation sessions and interviews with staff members were completed in casualty, the burns unit, plastic surgery ward, outpatient clinics, and other departments applicable to burns care (e.g. theatre, intensive care) to establish how patients with a burn injury obtain medical care at the hospital. Data included written field notes, photos, and diagrams. These were reviewed for commonalities and summarised in a narrative document. Repeat visits and interviews were conducted until all processes were understood. A process map was drawn using standard notation (Business Process Model and Notation 2.0 in Lucidchart software) to show the administrative processes applicable to admission and discharge of a patient with a burn injury, including which patients are entered into the handwritten burn register [23,24]. This was analysed to determine which patients are included and which are excluded from the register. Finally, the number of burn presentations recorded by casualty was compared to data recorded in the burn register to understand what proportion of cases are captured by the burn register.

2.5. Objective 2. Establish a process for digitisation that enables all register data to be readily analysed

Standard operating procedures were written for quality checking of scans, file naming, version control, and assignment of unique identification numbers. The aim of which was to ensure that the corresponding scan could be easily identified from each entry in the database. Digitisation was delayed until July 2021 due to hospital restrictions on research during the COVID-19 pandemic. Once research

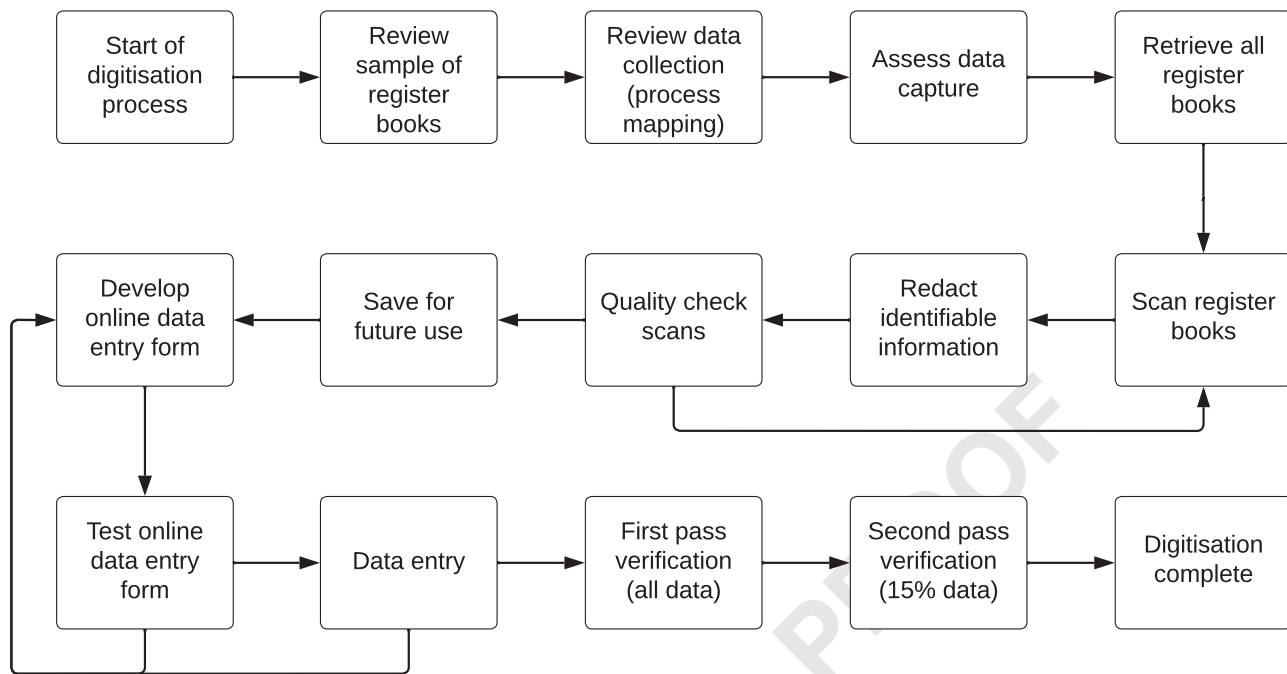


Fig. 1 – Steps followed to assess the suitability of a handwritten register for digitisation, the digitisation process, and quantification of the level of error during digitisation.

restrictions were lifted, register books were retrieved from the medical records department. Each page of the handwritten register books was scanned using an encrypted scanning application. Scanning was chosen rather than immediate transcription because it allowed the register books to be returned to the medical records department promptly and created a digital archive (e.g. for data verification). Scans were then collated into files corresponding to each month of the register book. Identifiable patient information was redacted using PDF editing software Wondershare PDFelement [25]. Redacted scans were transferred using an online encrypted large file transfer service WeTransfer and saved to a secure drive [26]. Each scan was reviewed to identify missing pages or unreadable data. Issues were logged in a spreadsheet and sent back to the scanning team for review and repeat scanning as required. Outcomes were logged and repeat scans saved to the secure drive. Optical character recognition software in Wondershare PDFelement was used on a sample of scans to trial automated data extraction, but no usable information was extracted due to the heterogeneous nature of the handwriting in the register books.

A data entry form was developed using the secure, web-based software platform, REDCap (see Appendix A – data entry form, Appendix B – code book) [27,28]. Fields were created using the maximal analysable data identified during the register review process. Categorical response options were used for as many questions as possible to reduce the burden of data cleaning prior to analyses. Categorical options developed using census information were used to code address data to allow rapid analyses (see Appendix C – India census address data). This included state, district, and taluk (local administrative unit typically comprising of a number of villages or an area of a city) for areas closest to the hospital.

The address was also entered as free text to ensure recording of data on villages and districts not included in the categorical coding, and to allow more detailed analysis in the future. Census information was used to cross reference free text address data and categorical options to ensure correct coding. Validation parameters were used where possible to reduce human error during data entry (e.g. age limited to 0 – 130 years). Questions that were left incomplete required the data entrant to choose a code to ensure that the cause of missing data were correctly attributed. These included unreadable, information not in the record, and not applicable. Dummy data were entered into the form to allow testing. Changes were made to the form to improve efficiency of data entry (e.g. use of radio buttons as opposed to drop down menus). Test analyses were completed on the dummy data using RStudio to ensure all fields were analysable [29]. Changes were made to the field names and response codes so that they were more intuitive for the analyst and therefore less likely to result in human error during analyses. Dummy data were deleted once testing was completed.

One member of the research team carried out data entry. Data were entered into the REDCap form from the register books scans. Each admission in the register book was assigned a unique research identification number that allowed the record to be tracked back to the appropriate scan. A log was kept of conventions followed for each field during data entry.

2.6. Objective 3. Quantify the level of error during the digitisation process

Verification was completed for all REDCap entries. First pass verification was completed once 12 months of data had been entered to ensure that issues were resolved, and solutions

applied, before further data were entered. Data were downloaded and automatic checks were used for fields with consecutive numbering (e.g. year, month, and page of the register book). Remaining fields were manually cross-checked against the scan of the register book to look for inconsistencies. Proofreading was chosen as the method of verification because it was significantly faster than double data entry. All identified errors were corrected. A log of errors was kept. A further 15% of records were checked to determine the remaining error in the digitised data. A random number generator was used to randomly select 15% of the total records [30]. These were checked by a second researcher who had not been involved in data entry. An error rate for data entry was calculated for each field following the first and second rounds of verification.

3. Results

3.1. Objective 1. Assess the suitability of a handwritten burn register for digitisation

A sample of register books showed that each volume covered a period of approximately 3 years. There were often multiple data fields entered under a single column heading (Table 1). All fields, except patient name and identifiable address data, were relevant to burns surveillance. Data fields were collected consistently within and across books, and missing data were estimated to be less than 5% per field.

Process mapping revealed that patients with a burn injury can self-present to the casualty or outpatient department of KR hospital (Fig. 2), which see 368,000 patients annually (data for 2019–2021). Outpatient registration is required for attendance to casualty or the outpatient department. This costs 10 rupees, which is approximately US \$0.12. KR hospital has a casualty rather than emergency department, the primary

function of which is to triage patients to the appropriate speciality and complete medicolegal processes. The Indian Government mandates that burn injuries must undergo medicolegal registration because they may require police investigation or legal proceedings to ascertain responsibility for the injury [31]. A Casualty Medical Officer completes medicolegal processes and then directs patients to the burn ward for specialist assessment. Patients who choose to attend the outpatient department rather than casualty are likely to be redirected by clinicians to casualty for medicolegal registration and specialist assessment. All burn injuries are assessed on the burn ward. Minor burns that do not require admission are treated on the burn ward as outpatients and are not included in the burn register. Patients that require inpatient burn care are included in the burn register. The register is completed by nurses upon admission of the patient to the burn unit (see grey symbol *burn register data collection point* Fig. 2). Admission criteria include all major burns (greater than 10% in adults, greater than 5% in children) and burns to sensitive areas (e.g. inhalational, hands, genitalia). Patients with inhalational burns are admitted to surgical intensive care initially but are transferred to the burn unit prior to discharge and thus are captured in the register. The admission process includes payment of a fee (200 rupees) for inpatient registration. This fee is higher than, and paid in addition to, the fee for outpatient registration. Staff recounted that occasionally patients do not return to the burn unit after being sent to complete inpatient registration and are thus not captured in the burn register.

Three volumes of register books were retrievable corresponding to admissions for February 2016 to February 2022. Older register books could not be located due to a shortage in medical record department staff during the ongoing COVID-19 pandemic. Complete data on the number of burn presentations was available from casualty for 42 months of 2018–2021 (Table 2). The number of burns cases recorded in

Table 1 – Column headings used in the handwritten register book and the data that was recorded under these headings. Identifiable information such as patient name and detailed address information were not included in the subsequent electronic register.

Register column heading	Extractable information
Patient admission number	Count of admissions to the burn unit that month Count of admissions to the burn unit that year Count of admissions to the hospital that year
Name	Patient name Patient address
Age	Age
Sex	Sex
Income	Income
Date of admission	Date of admission to hospital Time of admission to hospital Date of arrival at burn unit Time of arrival at burn unit
Nature of burn	Intent or mechanism of the burn Lower limit of total body surface area of the burn Upper limit of total body surface area of the burn
Date of discharge	Date of discharge Whether the discharge was against medical advice Whether the patient was transferred
Date of death	Date of death (if applicable) Time of death (if applicable)

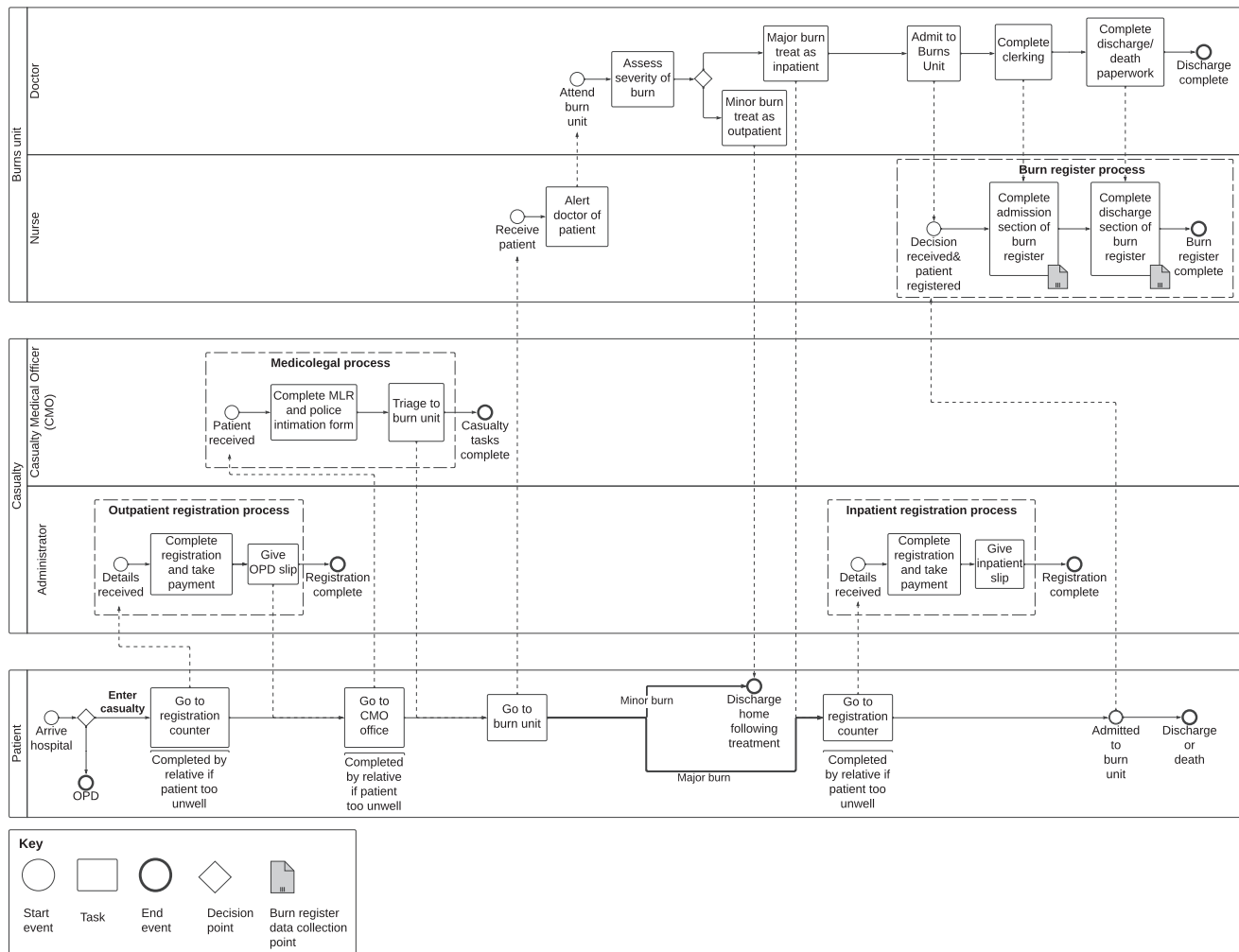


Fig. 2 – Process map showing the admission and discharge process for a patient with a burn injury, including completion of the handwritten burn unit register. Treatment processes (e.g. dressings, surgery, fluids) are not shown. The process map has been drawn using Business Process Model and Notation 2.0 (see key). The process map should be read from left to right. Each row (known as a lane) represents a participant in the process. Arrows show the direction of flow and connection between steps. Abbreviations: Casualty Medical Officer (CMO), Medicolegal register (MLR), Outpatient (OP), outpatient department (OPD).

the register was 95.4% of the number of burns presentations in casualty records.

These described and observed practices suggest that the population recorded in the burn register is consistent and that fields are completed in a uniform way. Overall, the initial review of the register suggested data were reliable and justified resource allocation for digitisation.

3.2. Objective 2 and 3. Establish a process for digitisation and quantify the level of error during the digitisation process

All pages (458) from register books were scanned. 20 pages were rescanned corresponding to an error rate of 4.4% during quality checking. This was due to 4 pages being missed, and 16 instances where some of the data were unreadable. Most issues were encountered early whilst processes were still being learnt and refined.

1930 patient admissions were recorded in the burn register and subsequently digitised covering the period of February 2016 to February 2022. This accounts for 0.84% of all admissions to the hospital. Each record took two to three minutes to enter onto the online data entry platform. During data entry it was found that the intent of the burn was sometimes overwritten (e.g. accidental changed to suicidal). This was felt to be a potentially significant observation because clinicians in the department reported encountering patients who changed their account of the circumstances of their injury and thus the entry in the register would also be changed. It was also found that for some entries patients were admitted to hospital at the same time and were from the same address, which may reflect a multi-casualty burn event. Additional fields were added to the data entry form to allow observations from the data entrant to be recorded.

Table 2 – Number of burn injury presentations recorded in casualty and in the burn register. (*Indicates years where there was incomplete Casualty data. Data missing for 5 months of 2019, and 1 month of 2020.).

		2018	2019	2020	2021
January	Casualty	40	37	21	21
	Burn register	41	36	20	24
February	Casualty	20	42	-	32
	Burn register	16	28	28	28
March	Casualty	37	31	27	23
	Burn register	31	30	23	29
April	Casualty	40	31	21	24
	Burn register	33	33	11	22
May	Casualty	27	38	20	17
	Burn register	23	28	17	15
June	Casualty	32	27	17	13
	Burn register	31	26	16	13
July	Casualty	21	24	8	22
	Burn register	18	27	13	22
August	Casualty	21	-	13	16
	Burn register	20	18	16	15
September	Casualty	42	-	11	34
	Burn register	32	23	15	23
October	Casualty	26	-	20	16
	Burn register	27	27	19	17
November	Casualty	41	-	21	28
	Burn register	34	29	20	27
December	Casualty	30	-	22	24
	Burn register	29	27	22	22
Total	Casualty	377	230 *	201 *	270
	Burn register	335	332	220	257

Each patient record took between 30 s and one minute to proofread. The error rate during first pass verification was 0.33% per field (Table 3). The most common errors were in numerical fields such as date of discharge and time of admission. Incorrect numerical data in the online data entry form was often auto filled by the computer browser and then accidentally inputted by the data entrant when moving between fields. Errors also occurred with time data due to register entries being completed using a 12-hour clock, requiring the data entrant to manually convert it to a 24-hour clock as required for analyses. Second pass verification identified five fields with errors, corresponding to a remaining error rate of 0.06% per field (Table 3).

4. Discussion

We have presented three methodological processes that will be of interest to anyone wishing to establish a burn register, as well as custodians and users of existing registers. The first is a method to assess the suitability and reliability of existing routinely collected data for surveillance purposes; the second is a method to digitise handwritten data; and the third is quantification of error during the digitisation process. For health systems operating using purely electronic data, the second method will not be applicable. We have exemplified these procedures by sharing our experience from a tertiary government burn unit in south India, but the methods are transferrable to any healthcare setting.

International guidance recommends that existing data is assessed prior to starting a new disease register as existing data may be sufficient to fulfil surveillance needs [12]. This should include an assessment of the quality and reliability of the data, but there is little information available on how to achieve this. In the first part of our paper, we address this issue by setting out a stepwise approach to assess data availability, data completeness, selection bias, and measurement bias in handwritten records. The method could also be applied to electronic data. Given the resources associated with starting a new burn register, utilisation of existing data may be a more sustainable solution particularly in resource limited locations. There is no global minimum recommended data set specifically for burn registers to help determine which routinely collected data might be most valuable [32]. The WHO Injury Surveillance Guidelines recommend a minimum data set comprising of 8 variables (identification number, age, sex, place of injury, activity when injured, mechanism of injury, intent, and nature of injury) [12]. The Burn Unit at KR Hospital had collected 20 variables (including 5 of the WHO's minimum surveillance data set) for over 20 years using existing resources. This provided information about which variables are feasible to collect and is invaluable for planning how a more detailed electronic register could be sustainably integrated into current practice. We found that the variables collected in the register were highly relevant to surveillance purposes. Inclusion of an analyst early in the process meant we were able to extract more data than anticipated - multiple fields were collected under each column heading of the register, overwriting of data, and probable multi-casualty events. Although the variables were applicable to surveillance it was essential to understand the quality of that data and potential sources of bias before committing to digitisation.

Selection bias is one of the more pervasive problems with utilising existing routinely collected data. A well-publicised limitation of routinely collected health data is that not all cases of interest may be captured. For example, national UK Hospital Episode Statistic data has been shown to undercount presentations of burn injuries, as well as other injury types such as self-harm, compared to their counterpart disease register that has a specifically designed case ascertainment strategy [33,34]. We found 95% of casualty cases were captured by the handwritten burn register. However, such numerical comparisons do not elucidate which patient populations may be missed. We used process mapping to understand possible sources of selection bias in more detail [22]. We found that patients with minor burns who are treated on an outpatient basis are not included in the handwritten burn register. This is in line with other burn registers internationally [33, 35–37]. Patients who abscond when asked to complete inpatient registration processes are also likely to be missed. All burn patients are required to completed medicolegal processes upon presentation to casualty at the hospital. It has been shown that burn patients show a preference for private hospitals due to fear that government hospitals are more likely to report the injury to the police [38]. These factors are likely to skew the data towards more severe burns and those who are unable to afford private care. They may

Table 3 – Errors identified during first and second pass verification with associated error rates.

	First pass verification	Second pass verification
Number of records checked	1930	290
Number of fields checked	50180	7540
Number of errors per field	-	-
SASHI event ID	2	0
Register book year	2	0
Register book month	5	0
Register book page	0	1
Number of patients presenting to burn unit that month year	16	0
Number of patients presenting to burn unit that year	19	0
Inpatient number	13	1
Full patient address	3	0
Patient address: country	0	0
Patient address: state	0	0
Patient address: district	0	0
Patient address: taluk	2	0
Patient age	9	0
Patient sex	3	0
Hospital admission unit	4	0
Income	1	0
Date of admission	9	0
Time of admission	20	0
Date received to burn unit	0	0
Time received to burn unit	14	0
Intent or cause of the burn injury	2	1
Lower limit of total body surface area of burn	5	0
Upper limit of total body surface area of burn	6	0
Discharge status	5	0
Date of discharge or death	22	2
Time of discharge or death	5	0
Total errors	167	5
Error rate per field	0.33%	0.06%

also exclude the poorest in society who cannot afford in-patient registration costs.

Large health data sets are recognised to be prone to such biases, yet detailed information on the limitations of the data are rarely described [39]. To tackle this issue, an extension to the Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines has been created specifically for studies using disease register data and other types of routinely collected data [40]. The Reporting of studies Conducted using Observational Routinely-collected Data (RECORD) extension recommends that observational studies using register data include details about sources of selection bias, but lack detail about how the researcher can achieve this [40]. Although we present our experience from a single centre, the systematic method used to understand the quality and reliability of data is equally applicable to large multicentre data sets.

Published epidemiological burn studies utilising register data or other sources of routinely collected data often lack sufficient detail on data collection and digitisation processes to allow the reader to determine reliability and potential utility of that data [36, 41, 42]. This may result in the “big data paradox” where the reliability of large data sets is incorrectly thought to be greater than that of smaller data sets [43]. We have included as much detail as possible in the manuscript to assist other institutions that wish to appraise and digitise a data set, this provides information tailored to individual burn units that would allow reporting of data in line with RECORD and STROBE guidelines.

Many burn registers use a manual process to input data into the register database [35,44]. Human error can occur when information is transferred from a record (e.g. patient notes, patient reported outcome measure form, survey) into a burn register database. Burn register database errors such as duplicate records, missing data, and internal inconsistencies have been found to affect a significant proportion of records, yet this information is rarely reported and may go unrecognised unless specific verification procedures are followed [45]. It is recommended that databases are designed to minimise human error during data entry, and records are checked for errors prior to completion of any analyses [45]. We explain in detail how we designed the database to minimise human error, as well as a process to explore and quantify the remaining error rate in the data. Our two-step verification process gave an estimated remaining error rate of 0.06% per field (i.e. 6 errors in every 10,000 fields), which is considerably lower than other register studies that have shown human transcription errors ranging from 0.5% to 26.9% per field [18, 19, 46].

There are some limitations to this study. We had hoped to retrieve all register books, but we were only able to retrieve books for 2016–2022 due to changes in medical records staffing during the COVID-19 pandemic. This does not, however, affect the transferability of the methods to other centres. We calculated case ascertainment of the burn register compared to casualty based on the number of cases. We were unable to compare the name or hospital number of the

patients to ensure the same cases were captured, however our process mapping exercise strongly supports the numerical results. We did not assess the accuracy of data entered into the handwritten register book beyond discussions with staff during process mapping. It is possible that there may be systematic errors such as misclassification of intent in the register, which we are aware is a sensitive issue in South Asia [38,47]. There are also likely to be simple non-systematic errors (e.g. incorrect date) [20]. This will be investigated and allowed for during analyses.

This project was funded by an international research grant. It is unlikely that government funded hospitals would have as much resource available to complete similar work. There were minimal consumables used in the project: existing computer hardware was used where possible; the encrypted file transfer service and data entry platform were free to use; but there was a one-off cost associated with using our chosen PDF editing software. The main cost associated with this work was staff salary. The bulk of the work (process mapping, operating procedure development, quality checks, data entry form development, data entry, first verification) was completed by a senior registrar with research experience, and a project manager (scanning, quality checks). The clinician researcher spent 2 days per week for 12 months on the project. The project manager spent 1 day per week on the project for 3 months. Input was gained from senior clinicians and researchers as required. A significant amount of this time was spent developing the methods used in the project. We have shared all relevant materials to streamline processes for those wishing to establish an electronic burn register from handwritten routinely collected data. Further materials and advice can be provided on request. Although we cannot demonstrate it on the basis of our data, we believe digitisation could be done on less than 50% of a junior clinician's time working under supervision.

We recommend that journals considering publication of observational burn studies based on digitised handwritten records ask for details on the how the quality of data were assessed, the digitisation process, and verification processes including estimated remaining error rates in the data. We recommend that process mapping is used as the technique to detail potential sources of selection bias in routinely collected burns data and that this is used in addition to any numerical estimate of case capture. We feel it would be beneficial to the global burns community if an international organisation with specialist knowledge of burn injuries produced a manual for establishing and maintaining electronic burn registers. The methods in this paper would be useful to guide a section on utilising existing handwritten data sources.

5. Conclusions

Routinely collected data is a potentially powerful source of data for a burn register but requires careful appraisal and conversion before it can be used. We have described, with real world examples from a newly established electronic

register in India, methods to assess the suitability and reliability of existing routinely collected data for surveillance purposes, to digitise handwritten data, and to quantify error during the digitisation process. The resources and methods used in the article are likely to be of particular interest to burns units in countries with no active national burn register. There is a growing emphasis for register studies to report data set limitations. Custodians and users of multicenter electronic burn registers may, therefore, also benefit from considering our pragmatic solutions to understand register population selection bias and human transcription errors.

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CRediT authorship contribution statement

MKa had the original idea. MKa, EB, RP, and CR refined the study idea. EB completed the process mapping exercise with help from MKa, SM, RR, MKr, RP, and CR. MKa, SN, SG, SM, RR, and MKr located and scanned the register books. EB, SG, and SN completed quality checks. EB designed the data entry form, completed data entry, and undertook first pass verification. RM completed second pass verification. EB completed analyses and drafted the manuscript. All authors have been involved in the revision of the manuscript and its final approval.

Declaration of Competing Interest

none.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.burns.2023.08.007](https://doi.org/10.1016/j.burns.2023.08.007).

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