What is “usual care” in the rehabilitation of upper limb sensory loss after stroke? Results from a national audit and knowledge translation study

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ABSTRACT

 Purpose: To characterise the assessments and treatments that comprise “usual care” for stroke patients with somatosensory loss, and whether usual care has changed over time.

 Materials and methods: Comparison of cross-sectional, observational data from (1) Stroke Foundation National Audit of Acute (2007–2019) and Rehabilitation (2010–2018) Stroke Services and (2) the SENSe implement multi-site knowledge translation study with occupational therapists and physiotherapists (n = 115). Descriptive statistics, random effects logistic regression, and content analysis were used.

 Results: Acute hospitals (n = 172) contributed 24,996 cases across audits from 2007 to 2019 (median patient age 76 years, 55% male). Rehabilitation services (n = 134) contributed organisational survey data from 2010 to 2014, with 7165 cases (median 76 years, 55% male) across 2016–2018 clinical audits (n = 127 services). Somatoensory assessment protocol use increased from 53% (2007) to 86% (2019) (odds ratio 11.4, 95% CI 5.0–25.6). Reported use of sensory-specific retraining remained stable over time (90–93%). Therapist practice reports for n = 86 patients with somatosensory loss revealed 16% did not receive somatosensory rehabilitation. The most common treatment approaches were sensory rehabilitation using everyday activities (69%), sensory re-education (68%), and compensatory strategies (64%).

 Conclusion: Sensory assessment protocol use has increased over time while sensory-specific training has remained stable. Sensory rehabilitation in the context of everyday activities is a common treatment approach.

 Clinical trial registration number: ACTRN12615000933550

 IMPLICATIONS FOR REHABILITATION

• Only a small proportion of upper limb assessments conducted with stroke patients focus specifically on sensation; increased use of standardised upper limb assessments for sensory loss is needed.
• Stroke patients assessed as having upper limb sensory loss frequently do not receive treatment for their deficits.
• Therapists typically use everyday activities to treat upper limb sensory loss and may require upskilling in sensory-specific retraining to benefit patients.

Introduction

Somatosensory loss is a common consequence of stroke, with 50–85% of individuals affected [1–4]. Upper limb somatosensory loss impacts the ability to detect, recognise and discriminate body sensations, such as touch, temperature, and proprioception, and integrate these sensations to identify objects in hand [5]. Impaired somatosensory is associated with reduced motor recovery [6,7] and activity participation after stroke [8]. Despite the high prevalence and impact of somatosensory impairment, somatosensory rehabilitation has been overshadowed by a historical focus on motor recovery after stroke. There is a known evidence-practice gap in somatosensory rehabilitation and the use of standardised assessments and evidence-based therapies is uncommon [9,10]. The use of standardised assessments in somatosensory rehabilitation is important, as the use of informal measures represents missed detection of somatosensory loss and lost opportunities for stroke survivors to receive treatment to regain lost somatosensation. Clinical practice guidelines for stroke...
recommend the use of standardised assessments for somatosensory loss [11] and evidence-based treatments including sensory-specific training [12,13], such as the sensory discrimination program, SENSe therapy [14].

Rehabilitation has been termed a black box, or even a “Russian doll” [15], in that it often involves ill-defined and layered complex interventions. Researchers, who conduct efficacy trials in rehabilitation will often use “usual” (or “standard”) care as a comparator when investigating a new intervention, though readers of the study may rightfully query: “but what is usual care?” The concept of usual care has been explored for a range of disciplines including speech pathologists in dysphagia rehabilitation [16], physiotherapists in the intensive care unit [17], and occupational therapists in cognitive rehabilitation [18]. Recently, the authors of a Cochrane systematic review explored usual care in stroke rehabilitation [19] and found considerable variation in terminology. They subsequently called the inadequate description of usual care an “unmanaged issue” in rehabilitation research [20]. Others have highlighted the lack of usual care information in stroke rehabilitation trials [21] and have called for this issue to be urgently addressed [22].

Common practice in somatosensory rehabilitation has been investigated in studies using self-report from healthcare professionals [9,10,23]. In these studies, occupational therapists and physiotherapists were surveyed about their typical approaches for the assessment and treatment of patients with somatosensory loss. Though informative, self-report of previous practice by healthcare professionals has potential shortcomings, such as recall bias. Clinical audits, which are more objective [24], have not been used to investigate practice patterns in somatosensory rehabilitation to date.

The Stroke Foundation National Audit (The Audit Program) has documented the care provided to patients with stroke presenting to Australian hospitals for over two decades [25] and includes questions on somatosensory assessment and treatment. The audit offers opportunities to monitor the quality of care and changes over time, to improve the delivery of evidence-based care [26]. Research regarding the impact of clinical audits and registries suggests they have a positive impact on healthcare processes and patient outcomes [27,28].

In knowledge translation studies, usual care is important as a baseline and comparator for behaviour change. The SENSe Implement study is an implementation trial in somatosensory rehabilitation, involving eight healthcare networks in Victoria, Australia [29]. The first phase of the study, the baseline period, was designed to observe characteristics of usual care provided to stroke survivors with somatosensory loss. Use of Phase One data for this purpose was planned as part of the SENSe Implement study and complemented national audit data to address the research questions in the current study.

The current study aimed to characterise the usual assessments and treatments used in somatosensory rehabilitation after stroke. This was addressed by summarising audit data from a national stroke audit and individual patient data from an implementation trial, to characterise and compare features of usual care in the assessment and treatment of somatosensory rehabilitation after stroke. The specific research questions were:

1. What are the somatosensory assessments and treatments reported to be used as part of usual care with stroke survivors?
2. What are the features of usual care somatosensory treatment provided by healthcare professionals as part of upper limb rehabilitation?
3. Is there evidence of change over time in the management of somatosensory loss in Australian national audit data?

Materials and methods
This observational study used cross-sectional data from two sources: the Australian Stroke Foundation National Audit program and an Australian knowledge translation study, the SENSe Implement study (Trial Registry ACTRN12615000933550) focused on post-stroke somatosensory rehabilitation.

National stroke audit – The audit program
Data were obtained retrospectively from hospitals participating in the Stroke Foundation audit of Acute (2007–2019) and Rehabilitation (2010–2018) Stroke Services. The audit alternates each year between acute and rehabilitation hospitals across Australia and has two components: an organisational survey and a clinical audit. The organisational survey includes questions on stroke service delivery and is completed by a clinician with knowledge of stroke services at each participating hospital. The clinical audit involves retrospective data extraction on patient characteristics, care, and outcomes from up to 40 consecutive individual stroke patient medical records from each audited site. Audit questions were developed through a national representative committee comprised of medical, nursing, allied health, and clinical research groups [30]. Included patients had a diagnosis of stroke (ICD-10 codes: 161, 162.9, 163, 164). Staff involved in the audit receive training and support in audit processes from the Stroke Foundation. A detailed description of the methods involved in both audit procedures has been published [26].

The audit is designed to determine adherence to stroke clinical guidelines and questions have changed over the years in line with updated guidelines. Therefore, questions of interest regarding somatosensory assessment and treatment were only included in certain audit periods. Consequently, for this study, both organisational and clinical data were included from the 2007 to 2019 acute audits, while only organisational data from 2010 to 2014, and clinical audit data from 2016 to 2018 of the rehabilitation audit were included. Clinical practice data were mapped across these years as an indicator of the stability of usual practice patterns. This is important for knowledge translation which aims for sustainable change relative to current practice. Supplementary Appendix 1 illustrates the questions available and used in this study. Data from the same audit questions across years were compared. To facilitate comparison between audited sites, only hospitals admitting >40 stroke patients per year were included. Questions on somatosensation were extracted from overall audit data. Where audit questions used the term “sensation,” additional information was sought from audit data dictionaries to confirm this related to somatosensation and not another sensory modality, such as vision.

Knowledge translation study – the SENSe implement study
Data were obtained from practice reports completed by healthcare professionals participating in the SENSe Implement study [29]. The SENSe Implement study is a multi-site (n = 8 healthcare organisations) knowledge translation study involving 115 stroke rehabilitation therapists (83% occupational therapists and 17% physiotherapists) working in sub-acute and community settings. The project has two phases; in Phase One therapists are provided with strategies to increase their use of a standardised upper limb
somatosensory assessment (while providing usual care treatment). In the second phase, therapists are supported to provide evidence-based somatosensory treatment, SENSe therapy [14]. Site involvement in the project was staggered and data from only Phase One of the project (2015–2019) were used in this study.

Participating SENSe project therapists completed a 2-page practice report for each stroke patient after providing their usual care treatment. The practice report was developed specifically for this study and was based on a previous national survey describing the contents of post-stroke somatosensory rehabilitation [9]. The practice report involved dichotomous questions (e.g., “Was the patient provided with treatment to address somatosensory loss?”), questions with multiple response options (e.g., “Indicate treatments used”) and free text questions (e.g., “Please briefly describe your therapy approach”).

**Data analysis**

Stata (Version 12, StataCorp, College Station, TX, USA) statistical software was used for all data analysis. Decision rules were first established regarding the national audit data; where responses to audit questions were not documented, these were either excluded (when questions related to the presence of an impairment) or assumed as a negative response (when questions related to a process of care). This method has been used in previous audit studies [31]. Aggregated data were then reviewed from participating hospitals and compared using chi-square tests. Multilevel random effects logistic regression analysis was used to assess organisational changes over time, with year of the audit included as an independent variable, and level defined as hospital. Adjustment for covariates was also included in the models for patient-level acute data (e.g., the sensory deficit on admission). Covariates considered for inclusion in the models were dependent on data collected in the respective acute or rehabilitation audits (Supplementary Appendix 2). These included: age; gender; pre-morbid function (modified Rankin Scale [32]); co-morbidities including previous stroke (acute only); stroke type, stroke severity [33]; cognitive impairment on admission (rehabilitation only); current function (Functional Independence Measure [34]) (rehabilitation only); and use of hospital protocols for sensory impairment (acute only). Variates with \( p \leq 0.1 \) on univariable testing were included in the final models. Odds ratios (ORs) and 95% confidence intervals were used to compare changes over time. Descriptive statistics were used for quantitative data from therapist practice reports. Data were exported from REDCap [35] to Stata (Version 12) for analysis.

A free-text clinical audit question on upper limb assessments used with individual stroke survivors was analysed inductively using summative content analysis [36]. Assessments were manually coded to categories corresponding to the purpose of assessments, such as assessments of “Strength,” “Sensation,” and “Dexterity.” Initial coding was completed by one researcher (LSC) and checked independently by a second researcher (YMY). Where there was disagreement or uncertainty, which occurred for three coding categories, the consensus was reached through consultation with a third researcher (LMC or NAL). To determine the frequency of upper limb sensory assessment use with stroke survivors, the denominator was the total number of upper limb assessments reported to be used through the audit and the numerator was the number of upper limb assessments used specifically for sensation.

Qualitative content analysis [37] was used to inductively code free-text answers from practice reports. A coding manual was developed from therapists’ answers by the primary author (LSC) (see Supplementary Appendix 3). An expert in the field of somatosensory rehabilitation (LMC) reviewed coding categories; changes to wording were recommended and incorporated. The “meaning unit” [37] for coding was a specific therapy approach (e.g., “education to protect limb” or “hot/cold retraining”). All qualitative data were coded independently by two researchers (LSC and YMY). Differences were found in 10% of coding decisions and discrepancies were discussed and resolved via consultation with a third researcher (LMC).

**Results**

**Somatosensory assessments and treatments used as part of usual care with survivors of stroke: evidence from the audit program**

Overall, 172 hospitals participated in the acute organisational survey from 2007 to 2019, and 24,996 cases were included in the clinical audit (137 hospitals). In the rehabilitation audit, 134 services participated in the organisational survey from 2010 to 2014, and 7,165 cases were included in the clinical audit from 2016 to 2018 (127 services). Refer to Supplementary Appendix 4 for an overview of sites contributing data per year and audit years where somatosensory data were collected. The characteristics of patients in acute and rehabilitation clinical audits are outlined in Table 1.

**Organisational survey**

Acute hospitals. The percentage of acute hospitals using locally-agreed sensory assessment protocols from 2007–2019 is outlined in Table 2. The use of assessment protocols increased year on year from 53% in 2007 to 86% in 2019. Random-effects logistic regression analysis exploring changes in the odds of hospitals reporting use of assessment protocols demonstrated significant improvement, with odds ratios ranging from 2.42 (95% CI 1.28–4.60) to 11.36 (95% CI 5.04–25.57) (Table 2).

Rehabilitation services. The percentage of rehabilitation services reporting the use of sensory-specific training was considered for three audit cycles (2010, 2012, and 2014). Use of this upper limb rehabilitation approach was reportedly high (90–93%) and was stable over the 6-year audit period. The reported frequency of use of sensory-specific training was most commonly rated as “usually” provided, across all audits (2010: 45%, 2012: 40%, 2014: 43%). Results from the multivariable analysis showed there was no significant difference in the odds of patients being provided with sensory-specific training during their inpatient rehabilitation stay in 2012 and 2014 compared to 2010 (Table 2).

**Clinical audit**

Acute hospitals. The number of patients with stroke presenting with somatosensory deficits on admission to hospital from 2009 to 2019 is provided in Table 2. Somatosensory deficits were documented in 48% of patients in 2009; this reduced to 35% in 2019. Random-effects logistic regression analysis exploring changes in the odds of patients being assessed as having sensory loss after adjusting for covariates, showed significant reductions in the years 2015, 2017, and 2019 compared to the reference year of 2009 [ORs 0.83 (95% CI 0.72–0.95); 0.68 (95% CI 0.59–0.78); and 0.65 (95% CI 0.57–0.75), respectively (Table 2)].

Rehabilitation services. Rehabilitation data were available for the assessment of sensory loss for two audit cycles (2016 and 2018) and involved 6,510 cases. After adjusting for clinical covariates, the
Table 1. Stroke Foundation National Audit program: characteristics of patients with stroke.

**Acute clinical audit**

| Patient characteristics | 2007 n = 2663 | 2009 n = 3214 | 2011 n = 3415 | 2013 n = 3576 | 2015 n = 4012 | 2017 n = 4090 | 2019 n = 4026 |
|-------------------------|---------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                         | N = 81 hospitals | N = 88 hospitals | N = 95 hospitals | N = 108 hospitals | N = 107 hospitals | N = 112 hospitals | N = 105 hospitals |
| Male                    |               |               |               |               |               |               |               |
| Age, years, median      | 1390 (52)     | 1693 (53)     | 1815 (53)     | 1952 (55)     | 2203 (55)     | 2249 (55)     | 2286 (57)     |
| Aboriginal or Torres    |               |               |               |               |               |               |               |
| Strait Islander         | 33 (1)        | 64 (2)        | 97 (3)        | 113 (3)       | 106 (3)       | 96 (2)        | 136 (3)       |
| Independence prior to    | 2128 (82)     | 2002 (68)     | 2273 (73)     | 2388 (73)     | 3210 (80)     | 3292 (80)     | 3311 (82)     |
| stroke (mRS 0–2)        |               |               |               |               |               |               |               |
| Pre-stroke history       |               |               |               |               |               |               |               |
| Prior history of stroke/TIA | 861 (35)     | 1000 (37)     | 1138 (40)     | 1027 (34)     | 1241 (35)     | 1177 (31)     | 1156 (30)     |
| Hypertension            | 1785 (71)     | 2119 (72)     | 2298 (74)     | 2398 (73)     | 2624 (70)     | 2700 (69)     | 2652 (68)     |
| Diabetes                | 577 (24)      | 739 (27)      | 824 (29)      | 901 (30)      | 989 (28)      | 985 (26)      | 1088 (28)     |
| Hypercholesterolemia    | 888 (40)      | 1174 (45)     | 1372 (51)     | 1413 (48)     | 1489 (43)     | 1571 (42)     | 1565 (41)     |
| Atrial fibrillation     | 668 (28)      | 816 (27)      | 955 (36)      | 1022 (29)     | 1002 (27)     | 1009 (26)     | 1009 (26)     |
| Stroke type             |               |               |               |               |               |               |               |
| Ischaemic               | 757 (32)      | 803 (30)      | 904 (34)      | 899 (31)      | 991 (29)      | 944 (25)      | 961 (25)      |
| Haemorrhagic            | 861 (35)      | 1000 (37)     | 1138 (40)     | 1027 (34)     | 1241 (35)     | 1177 (31)     | 1156 (30)     |
| Under determined        | 334 (13)      | 500 (16)      | 512 (15)      | 419 (12)      | 541 (13)      | 503 (12)      | 478 (12)      |
| Stroke severity indicators |             |               |               |               |               |               |               |
| Speech/communication    | 1657 (66)     | 2012 (67)     | 2049 (64)     | 1730 (56)     | 2248 (59)     | 2243 (57)     | 2183 (56)     |
| deficit on admission    |               |               |               |               |               |               |               |
| Arm deficit on admission| 1904 (74)     | 2208 (71)     | 2289 (70)     | 2325 (67)     | 2366 (62)     | 2356 (60)     | 2343 (60)     |
| Unable to walk on       | 1660 (66)     | 2155 (69)     | 2162 (64)     | 2389 (69)     | 2161 (55)     | 2112 (54)     | 2206 (56)     |
| admission               |               |               |               |               |               |               |               |
| Incontinence within 72 h| 962 (38)      | 1298 (43)     | 1289 (40)     | 1277 (37)     | 1333 (34)     | 1250 (35)     | 1231 (31)     |

**Rehabilitation clinical audit**

| Patient characteristics | 2008 n = 2119 | 2010 n = 2985 | 2012 n = 2621 | 2014 n = 3081 | 2016 n = 3514 | 2018 n = 3651 |
|-------------------------|---------------|---------------|---------------|---------------|---------------|---------------|
|                         | N = 68 services | N = 97 services | N = 101 services | N = 103 services | N = 108 services | N = 109 services |
| Male                    | 1129 (53)     | 1613 (54)     | 1533 (54)     | 1655 (54)     | 1962 (56)     | 1995 (55)     |
| Age, years, median      | 75 (64, 82)   | 76 (65, 83)   | 76 (66, 83)   | 76 (66, 84)   | 76 (66, 84)   | 76 (66, 83)   |
| Aboriginal or Torres    | 35 (2)        | 63 (2)        | 55 (2)        | 54 (2)        | 73 (2)        | 83 (2)        |
| Strait Islander         | 167 (8)       | 254 (9)       | 198 (7)       | 261 (9)       | 391 (11)      | 348 (10)      |
| Independence on         |               |               |               |               |               |               |
| admission (mRS 0–2)     |               |               |               |               |               |               |
| Stroke type             |               |               |               |               |               |               |
| Ischaemic               | 1671 (79)     | 2302 (77)     | 2136 (76)     | 2391 (78)     | 2788 (79)     | 2620 (72)     |
| Haemorrhagic            | 340 (16)      | 512 (17)      | 519 (18)      | 532 (17)      | 656 (19)      | 605 (16)      |
| Under determined        | 108 (5)       | 171 (6)       | 166 (6)       | 158 (5)       | 70 (2)        | 426 (12)*     |
| Stroke severity indicators |             |               |               |               |               |               |
| Speech/communication    |               |               |               |               |               |               |
| deficit on admission    |               |               |               |               |               |               |
| Arm deficit on admission|               |               |               |               |               |               |
| Unable to walk on       |               |               |               |               |               |               |
| admission               |               |               |               |               |               |               |
| Incontinence within 72 h|               |               |               |               |               |               |

TIA: transient ischaemic attack; mRS: modified Rankin Scale; * question changed and also included "other" type; “–” question not asked in audit cycle.

The proportion of patients with stroke found to have sensory loss was 42% in 2016, decreasing to 39% in 2018 (OR 0.75, 95% CI 0.67–0.85). Responses to a free-text question regarding the use of upper limb assessments found 2634 entries, with 3558 individual upper limb assessments listed. Of this total, 222 (6%) were somatosensory assessments. This compares to 776 (21%) assessments of strength and 448 (12.6%) assessments focusing on upper limb assessment within functional tasks. See Table 3 for a comparison of upper limb sensory assessments and the frequency of the ten most used assessment categories. Detail on the type of sensory assessment conducted was rarely provided (<15%).

Somatosensory treatments used in usual care with survivors of stroke: evidence from the SENSe implement knowledge translation study

Practice reports were completed by therapists for 86 of the 90 patients enrolled in the study (95% response rate). Characteristics of stroke
survivors with somatosensory loss seen by therapists are summarised in Table 4. Overall, 84% of patients \((n = 72)\) were provided with some form of somatosensory rehabilitation. Conversely, 16% of patients \((n = 14)\) with identified sensory loss did not receive any somatosensory rehabilitation. Figure 1 provides a summary of the provided interventions.
The most frequently reported interventions were: sensory rehabilitation in the context of everyday activities (69%), sensory re-education (68%), and compensatory strategies (64%). The use of evidence-based treatments, such as a sensory-specific discrimination program, was less common (ranging from 1 to 18%).

Content analysis of qualitative descriptions of therapy revealed broad categories of treatments (see Supplementary Appendix 3 for coding manual). Therapy involving occupational and goal-directed tasks were the most common means of providing somatosensory rehabilitation: e.g., “occupation focus – using prayer beads & using sensation to assist with smooth movement” (Therapist 67) and “occupation-based – cutlery use” (Therapist 52).

A focus on specific aspects of somatosensory function, namely texture discrimination, and object identification, were also commonly coded categories: e.g., “encouraged patient to … discriminate between different textures” (Therapist 2) and “patient agreed to pick objects out of bag and try to identify without looking. Once guess was provided, patient could look at object” (Therapist 14).

Patient-directed somatosensory rehabilitation was also a frequently coded category, with the patient and/or their carer provided with methods to facilitate their own therapy: e.g., “provided with sensory kit — 2 x balls, tea bag, spoon, texta/marker, buttons, coins and sheet to record how quickly patient was able to accurately identify object (without using vision to compensate)” (Therapist 14) and “involved partner for randomisation of presentation of objects” (Therapist 5).

### Table 4. SENSE implement knowledge translation study: characteristics of stroke patients receiving usual care somatosensory rehabilitation.

| Knowledge translation study | Stroke patient characteristics (n = 86) |
|-----------------------------|---------------------------------------|
|                             | n          | %       |
| Age (years)                 | 61 (M)    | 15.9 (SD) |
| Sex                         |            |          |
| Female                      | 33         | 38       |
| Male                        | 53         | 62       |
| Side of lesion              |            |          |
| Left hemisphere             | 39         | 45       |
| Right hemisphere            | 43         | 50       |
| Unknown                     | 4          | 5        |
| Stroke type                 |            |          |
| Ischaemic                   | 57         | 66       |
| Haemorrhagic                | 19         | 22       |
| Unknown                     | 10         | 12       |
| Setting                     |            |          |
| Inpatients                  | 28         | 33       |
| Outpatients                 | 51         | 59       |
| Unknown                     | 7          | 8        |

M: Mean; SD: standard deviation.

### Discussion

Our findings demonstrate that the use of health organisation protocols to assess somatosensory impairment increased by 33% from 2007 to 2019, yet therapist practice reports revealed that almost one-in-five stroke survivors assessed as having somatosensory loss are not provided with any specific treatment to address their impairment. Assessment of somatosensory impairment comprises 6% of all upper limb assessments completed with stroke survivors, and details or types of somatosensory assessments are rarely documented. In terms of treatment practices, this study found >90% of organisations reported using sensory-specific retraining and maintained this use over several audit cycles. The most commonly reported approaches to treatment were sensory rehabilitation in the context of everyday activities, sensory re-education, and compensatory strategies. A low percentage (18%) of evidence-based treatments are used for somatosensory loss.

These results align with previous research, for example, the increased use of sensory assessment protocols may reflect a growing recognition of the importance of addressing post-stroke somatosensory loss [38,39]. However, audit data does not detail the

Figure 1. SENSE implement knowledge translation study: type and frequency of somatosensory treatments used with patients. *The number of participants does not sum to 72 and proportions do not sum to 100% as questions had multiple response options.
components of sensory assessment protocols, so it is unclear from our study which areas of somatosensation are addressed within usual care, or the type and quality of measures used. This makes interpreting the reduced number of patients found to have a somatosensory loss in this study, compared to the reported prevalence of somatosensory loss (>50%) in other research [2,3], challenging. Assessments used clinically for somatosensation are known to be less sensitive than standardised assessments used in research, and the “miss rate” for detecting somatosensory loss is considered to be high [1,4]. Therefore, an ongoing clinical shift towards the use of standardised somatosensory assessments—a means for stroke survivors to enter into somatosensory rehabilitation—is critical.

Sensory-specific training is recommended in clinical practice guidelines for stroke [12]. This study found >90% of organisations reported using sensory-specific training and maintained this use over several audit cycles. It should be noted however that this is based on self-reported organisational data rather than patient-level clinical data. This may account for these findings being at odds with previous research which shows sensory-specific training is underutilised [9,10].

The finding that somatosensory assessments are used less frequently and documented in less detail than motor assessments is perhaps unsurprising; other authors have commented on the historical precedence given to motor impairment after stroke [38,40]. We were unable to determine specific somatosensory assessments used through national audit data, as the names of specific assessments were often not provided, though it is interesting that sensory assessment featured in the top ten upper limb assessments used with stroke survivors. It should be noted that other discipline-based assessments in the top 10 (occupational therapy and physiotherapy assessment) may have comprised some aspect of somatosensory assessment that was undocumented and therefore not extracted by the audit.

Both quantitative and qualitative data from therapist practice reports in the knowledge translation study revealed that the delivery of “usual care” somatosensory rehabilitation is within the context of everyday activities. This may suggest a need for somatosensory rehabilitation to fit with concurrent rehabilitation priorities of therapists and patients rather than being a “stand-alone” approach, but it may also be because of a lack of knowledge and training in somatosensory rehabilitation techniques. Unfortunately, it is not clear what “within the context of everyday activities” means and whether any specific sensory discrimination training principles are applied. The gap between evidence and practice in somatosensory rehabilitation has been established [9,10] and the need for knowledge translation initiatives is acknowledged [29]. However, somatosensory rehabilitation may not need to be delivered as a stand-alone approach. Combining sensory-specific therapy with other approaches, such as motor retraining and task-specific training, has been recently investigated [41,42] with a suggested positive initial effect on upper limb outcomes [42]. Studies combining sensory-specific and motor therapies have, to date, been limited by small sample sizes and improvements following therapy have not been sustained at 3-6 month follow-up [42,43]. In the future, an integrated, evidence-based sensorimotor rehabilitation approach may have clinical acceptability for therapists and patients alike.

Another prominent feature of usual care was the use of home programs for somatosensory rehabilitation. This may reflect an increased focus on the patient’s role in self-management of their rehabilitation, the time constraints of busy therapists, or an awareness of the higher “dose” that is likely required for optimal upper limb outcomes. Also of interest, is the high frequency of texture discrimination and object identification retraining in usual practice. It should be noted that therapists in the knowledge translation study had been provided with training and equipment to conduct standardised assessments of texture discrimination and object identification. Training therapists to identify distinctive somatosensory impairments probably increases their likelihood of then treating these deficits specifically. Future research should determine the effects of a knowledge translation strategy on change in “usual care” somatosensory rehabilitation and the treatment outcomes of stroke survivors with somatosensory loss across a range of clinical practice settings.

The current findings should be interpreted within the context of study limitations. Combining audit data across years had benefits in providing a nationally representative sample with greater generalisability. However, it is acknowledged that the characteristics of patients and hospitals involved may have differed across years. Aspects, such as age, gender, and stroke severity were included, however, we were not able to account for all co-morbid confounders (for example cognition) as some information was not available for all years of the audit. Also, some organisational data of interest in the rehabilitation audit were only collected in three audit cycles (2010–2014) and may not reflect more recent practice; though it does provide some insights. The accuracy of clinical audit data is also dependent on original documentation by healthcare professionals, and we acknowledge under-documentation or variable documentation may have impacted results. Potential differences between hospitals in the audit could have been further mitigated by using matched analysis, though this would have reduced the overall size of the study and the ability to explore national changes over time.

Using the baseline “usual care” practice reports from the knowledge translation study provided the opportunity to understand the in-depth and individualised data on therapy provided to a stroke patient. However, it should be acknowledged that participating therapists were enrolled in the SENSe Implement study and were involved in a knowledge translation process that aimed at changing practice in somatosensory assessment. We acknowledge, therefore, that this may have influenced their approach to usual care treatment.

**Conclusions**

There has been an increase in organisational assessment practices for somatosensation over the last decade. Assessment of somatosensation comprises a small percentage of upper limb assessments conducted with stroke survivors. Non-specific sensory rehabilitation in the context of everyday activities is the most common approach in usual care treatment for stroke survivors with somatosensory loss. The use of evidence-based sensory interventions remains low. A substantial number of stroke survivors with somatosensory loss do not receive any treatment for their impairment. The characterisation of usual care in somatosensory rehabilitation provides an important comparator for future practice change.

**Acknowledgements**

We acknowledge the hospitals participating in the National Stroke Audit and the clinicians who contributed to data collection using the Australian Stroke Data Tool (AuSDat). We acknowledge the work of Monique Kilkenny for her role in the Stroke Foundation National Audit program. We acknowledge and thank the
occupational therapists and physiotherapists who took the time to complete practice reports for their patients in the SENSe Implement study.

**Ethical approval**

Ethics approval for data used in this project was granted through Monash University Human Ethics Committee (Project ID 8842) (Study 1, The Audit Program), and from Austin Health Human Research Ethics Committee (H2013/04956 HREC/13/Austin/8) and La Trobe University Human Ethics Committee (FHEC 14/243) (Study 2, The SENSe Implement Study).

**Author contributions**

LSC, DC, NAL, and LMC conceptualised the study. TP and LSC conducted data analysis of national audit data. LSC and YMY were involved in data collection and analysis in the knowledge translation study, with supervision and adjudication from LMC. LSC drafted the manuscript. All other authors (DC, LMC, NAL, DOC, TP, and YMY) read the manuscript and provided feedback for revision.

**Disclosure statement**

LMC is the lead originator of the SENSe approach to sensory rehabilitation, the focus of knowledge translation in The SENSe Implement project. LMC has no personal financial interest in the sale of the SENSe training package (manual and DVD). There is no patent, or intended application for a patent, associated with these resources. All other authors declare that they have no competing interests.

**Funding**

This work was supported by National Health and Medical Research Council (NHMRC) of Australia partnership grants: A network of sites and “up-skilled” therapists to deliver best practice stroke rehabilitation of the upper limb (GNT1134495) and Ideas grant: Staying connected: personalising stroke recovery and rehabilitation through new technologies for people with stroke living at home (GNT143480). LSC and YMY are supported by La Trobe University Post-Graduate Scholarships. NAL is supported by a Future Leader Fellowship (102055) from the National Heart Foundation of Australia. DAO is supported by La Trobe University Human Ethics Committee (FHEC 14/243) (Study 2, The SENSe Implement Study).

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