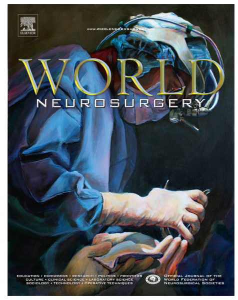

Mapping the clinical pathway for patients undergoing vestibular schwannoma resection

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Short title: Pathway for vestibular schwannoma resection

Abbreviations: CSF: cerebrospinal fluid, **EHR:** electronic health records, **HDU:** High dependency unit, **ICU:** intensive care unit, **IRB:** institutional review board, **NLP:** natural language processing, **NF2:** Neurofibromatosis 2, **QoL:** quality of life, **VS:** Vestibular schwannomas

Title Page

Mapping the clinical pathway for patients undergoing vestibular schwannoma resection

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ABSTRACT

Background: The introduction of electronic health records (EHR) has improved the collection and storage of patient information, enhancing clinical communication and academia. However, EHRs remain limited by data quality and the time-consuming task of manual data extraction. This study aims to utilise process mapping to help identify critical data entry points within the clinical pathway for VS patients, ideal for structured data entry and automated data collection, in an effort to improve patient care and research.

Methods: A two-stage methodology was conducted at a neurosurgical unit. Process maps were developed using semi-structured interviews with stakeholders in the management of VS resection. Process maps were then retrospectively validated against EHR for patients admitted between August 2019 and December 2021, establishing critical data entry points.

Results: Twenty stakeholders were interviewed in the process map development. Process maps were validated against the EHR of 36 patients admitted for VS resection. Operation notes, surgical inpatient reviews (including ward rounds) and discharge summaries were present for all patients, representing critical data entry points. Areas for documentation improvement were present in the preoperative clinics (30/36, 83.3%), preoperative skull base multidisciplinary team (32/36, 88.9%), postoperative follow-up clinics (32/36, 88.9%), and the postoperative skull base multidisciplinary team meeting (29/36, 80.6%).

Conclusion: This is a first use of a two-stage methodology for process mapping the clinical pathway for patients undergoing VS resection. Our study identified critical data entry points which can be targeted for structured data entry and for automated data collection tools, positively impacting patient care and research.

INTRODUCTION

Vestibular schwannomas (VS) are skull base tumours which can be managed with surveillance, radiation therapy or surgery.[1] Patients with VS are often managed by a multidisciplinary team, including neurosurgeons, otorhinolaryngologists, nurse specialists, and therapists.[1,2] In addition, VS patients can have long inpatient stays, with intensive care admissions and complications.[3] Data is a scarce and crucial resource for VS patients given the low volume of cases.[4] The introduction of electronic health records (EHR) has greatly improved the collection and storage of VS patient information proving vital for evidence-based decision making and academia, while also improving communication among healthcare professionals.[4–7] However, the EHR remains limited by the quality of data entered and the time-consuming task of manual data extraction when conducting audits, quality improvement projects and research.[8–12]

The challenges associated with EHR can be addressed through two approaches. Firstly, the use of structured data entry offers a solution to improving data accuracy. This can be achieved through customised templates, which guide users to enter essential clinical information into the EHR, subsequently enhancing communication among healthcare professionals and improving patient care.[13–15] Secondly, the use of automated data collection tools can greatly reduce the time taken to acquire valuable patient information while maintaining quality and reducing human error.[10,16,17]

To aid the successful implementation of structured data entry and automated data collection, the identification of critical data entry points within the patient clinical pathway is required. This can be achieved through process mapping; a system engineering methodology which offers insight into the "current state" of a system.[18–20] Process mapping aims to establish a shared understanding of any given system. The success of process mapping is evident across the manufacturing and service industries, with its use within healthcare growing in popularity.[20–22] In addition, process mapping has already been applied to pituitary adenoma surgery within our centre, in which the clinical pathway requires a multidisciplinary team approach similar to that of VS surgery. Mapping the clinical pathway for patients undergoing pituitary surgery helped identify critical data entry points as a first step towards automated data collection.[12]

In this study we aim to (1) establish the current state of the management of VS patients utilising a process mapping methodology; (2) identify critical data entry points within the patient pathway which may benefit from structured data entry and automated data collection, improving research, audits, and patient care.

METHODS

Study design

This study utilised the framework set out by Antonacci et al. and methodology devised at our centre by Hanrahan et al.[12,20] A two-stage, mixed methods study protocol was conducted incorporating qualitative and quantitative methods between October 2022 and March 2023. The patient cohort included all individuals undergoing VS resection at a single neurosurgical unit. Exclusion criteria included patients initially referred under the age of 18, referred before the inception of EHR, histopathological proven to be non-vestibular schwannomas, private patients, and patients with previous interventions for their VS (surgery or Gamma Knife radiosurgery). Patient pathway events were captured from initial referral through to outpatient follow-up.

Process map development

The process maps were divided into three stages: (1) presentation to operation, (2) operation to discharge and (3) discharge to follow-up. Initial VS process maps (Version 1) were designed by the first and last author. These process maps were subsequently reviewed by stakeholders through semi-structured interviews. A purposive snowball sampling methodology was employed, where initial stakeholders were selected from individuals present within the lateral skull base multidisciplinary team meeting with a direct involvement in VS management. Additional stakeholders were then further identified through semi-structured interviews with stakeholders.[23,24] The use of stakeholders from the lateral skull base multidisciplinary team allows for creation of VS specific process maps and is a key adaptation to the methodology when comparing to the framework utilised in previous work.[12] Semi-structured interviews involved completion of a five-item questionnaire which elicited baseline characteristics, perceptions and feedback from stakeholders (Supplementary material 1). During interviews, stakeholders annotated version 1 process maps (Figure 1). Annotations were then reviewed by joint first authors independently and were accepted or rejected. Conflicts between the two authors were discussed to reach consensus, with disagreements resolved by the senior authors to produce version 2. The final version 2 process maps were reviewed by lead and senior authors prior to real-world data validation.

Process map validation

The period of interest was August 2019 and December 2021 to ensure sufficient time for patients to progress through the clinical pathway from initial presentation to follow-up.

Version 2 of the process maps were then retrospectively validated against EHRs of 50 consecutive patients admitted for VS surgery (Figure 1). This allows for the comprehensive incorporation of the process maps alongside the qualitative feedback collected from stakeholders. The sequence of events for each patient during their primary admission for VS resection were compared between the EHR and the version 2 process maps to identify any discrepancies (1 = agreement, 0 = disagreement). This task was conducted by lead authors (SS and SW). Any uncertainties in the sequence of events were first clarified amongst lead authors and then senior authors if required.

Identifying critical data points

Critical data points were identified based on the presence or absence of an event within each patient's medical record (even if only present once). Critical data points were grouped by frequency (100%, 90 – 99%, 80 – 89% and <80%). For example, if a 'Neurosurgical Clinic' was present in 19 of 20 patient records, it would be calculated to have occurred in 95% and would be identified as a critical data point. These thresholds were derived from previous process mapping research. Furthermore, the total frequency of events was also recorded.[12,25]

Ethical approval

This study was approved and registered locally as a service evaluation project and had no bearing on patient management with no identifiable patient data presented. Therefore, no patient consent or approval from the institutional review board (IRB)/ethics committee was required. Stakeholders involved, gave written informed consent to participate within the study.

RESULTS

Process map development

The lead and senior authors initially constructed three process maps (Version 1) visualising the patient pathway from presentation to operation (Process map 1), inpatient management (Process map 2), and outpatient follow-up to discharge from neurosurgical services (Process map 3). Version 1 of the process maps were reviewed by twenty stakeholders with a combined experience of 149 years in managing patients undergoing VS resection. Sixteen stakeholders came from the neurosurgery (10, 50%) or otorhinolaryngology (6, 30%) departments, mostly consisting of senior clinicians and junior trainees (15, 75%) (Table 1). A total of 104 process map annotations were documented following stakeholder interviews. Initial consensus was achieved in 103 annotations (99.04%), with 1 (0.96%) annotation requiring further input from senior authors. Following this, 56 (53.85%) annotations were incorporated into version 2 of the process maps with 48 (46.15%) rejected. The version 2 maps were reviewed by both lead and senior authors prior to real-world data validation.

Real-world dataset

A dataset of 50 patients that underwent VS resection between August 2019 and December 2021 was collated (Table 2). The median age was 57.5 years, with a gender ratio of 29 males to 21 females. The most common presenting symptoms was hearing loss (34/50, 68%) followed by gait disturbance (22/50, 44%). The majority of patients underwent a retrosigmoid approach (27/50, 54%), with the remaining undergoing translabyrinthine (22/50, 44%) and transotic approaches (1/50, 2%). The median length of stay was 8 days.

There were 20 postoperative complications across 16 patients (16/50, 32%), of which the most common was cerebrospinal fluid (CSF) leak, occurring in 9 patients (9/50, 18%). Management for CSF leaks included three patients undergoing wound revision in theatre, one patient having a lumbar drain inserted and five patients having both a lumbar drain insertion and wound revision in theatre.

Facial weakness was present in 5 patients preoperatively (5/50, 10%). Of the 45 patients without pre-operative facial weakness, 16 patients (16/45, 35.6%) developed early facial nerve palsy postoperatively, of which the majority recovered. Late facial nerve palsy was only present in 3 patients (3/45, 6.7%) at long term follow-up.

Process map validation

Fourteen patients were excluded from analysis (six private patients, five previous resections before the establishment of EHR and three previous gamma knife treatments). Overall, 2356 individual events (such as a ward round) were recorded across the cohort, with 97 discrete event categories identified (Supplementary material 2). A mean percentage of agreement from the 36 patients analysed was 90.4% (61.2 to 100%) when sequence of events in the process maps were compared to the EHR.

Critical datapoints

The process by which patients underwent VS resection was plotted in three process maps. Figure 2 represents presentation to health services to operation, Figure 3 captures operation to hospital discharge and Figure 4 visualises the outpatient setting from hospital discharge to discharge from skull base services. Of the 2356 individual events, the most common was surgical review as inpatient (N = 420, 17.8% of all events) of which 278 were neurosurgical ward round entries and 142 were non-ward round related surgical entries. Following this, frequently occurring events were inpatient therapy team input (N = 351, 14.9%) which included physiotherapy, occupational therapy, dietician and speech and language therapy. Postoperative follow-up clinic entries were the third most commonly documented event (N = 162, 6.9% including neurosurgery, otorhinolaryngology and combined skull base clinic).

Critical data entry points were identified following the recording of the presence or absence on an event. Operation notes, surgical review (including ward round entries) and discharge summaries were present for all 36 patients (Figure 2). Physiotherapy and occupational therapists ward reviews were present in 35/36 patients (97.2%), with referral imaging and surveillance imaging present in 33 (91.7%) and 34 (94.4%) patients respectively. An initial admission clerking was present in 34 patients (94.4%). Preoperative skull base multidisciplinary team meeting documentation was present in 32 patients (88.9%). Furthermore, documentation was present for preoperative surgical clinics in 30 patients (83.3%), postoperative follow-up clinics in 32 patients (88.9%), and postoperative skull base multidisciplinary team meeting in 29 patients (80.6%).

Of the 21 patients that were admitted to HDU/ICU following their operation, there was a critical care admission clerking and ward round review in all patients (100%), with a discharge summary for 20 patients (95.2%).

DISCUSSION

Principal findings

To our knowledge, these are the first validated process maps of patients undergoing VS resection at a tertiary neurosurgical unit. Utilising the framework set out by Antonacci et al. and methodology from Hanrahan et al. our process maps were created using semi-structured interviews with key stakeholders within the lateral skull base team, followed by real-world patient dataset validation.[12,20]

Through process mapping, our study identified critical data points within the VS resection pathway, which can be targeted for structured data entry. Critical events included neurosurgical ward round entries, operative notes, discharge summaries and therapy reviews, which were present in >90% of VS patient's EHRs. Patients admitted to the ICU had additional data entry points, such as ICU admission clerking, ward rounds and discharge summaries. Significantly, by identifying critical data entry points, we acknowledge the potential of template driven data entry. Our future aim would be to implement set templates facilitating improved documentation quality and patient safety. Template-driven documentation would be targeted at capturing key clinical information. For example, for VS patients, this would include improved documentation of surgical complications, such as CSF leak or facial nerve palsy. Furthermore, identifying critical data points facilitates for potential automated data retrieval, enhancing both audits and research. Through automated data collection, trends in complications and outcomes can be better captured helping feed into the national VS registry, informing ways to improve and standardise clinical management.[26] In addition, given the variation for both annual caseload of VS resections and the number of surgeons who perform the procedure at each unit, our process maps can act as an exemplar for low-volume centres or a point of comparison for other centre's processes.[4] Furthermore, process mapping can also be used for national service delivery pathways, specifically relating to Neurofibromatosis type 2 (NF2), helping identify critical data entry points within this patient cohort, in the context of VS surgery.[27] Finally, as core outcomes sets are developed and utilised, the use of standardised data entry can increase homogeneity in reported clinical outcomes for research and audit purposes.[28,29]

Additionally, areas for documentation improvement were also highlighted. An initial admission clerking was documented in 34/36 patients (94.4%). Failure to document an admission clerking may lead to the absence of baseline patient characteristics in the notes, and potentially delay surgery if preoperative investigations are not acknowledged or completed.[30–33] Clear areas for documentation improvement were also identified in the preoperative surgical clinics (30/36, 83.3%), preoperative skull base multidisciplinary team meetings (32/36, 88.9%), postoperative follow-up clinics (32/36, 88.9%), and postoperative skull base multidisciplinary team meetings (29/36, 80.6%), all of which can impair communication among healthcare professionals.

This study highlights the positive impact of process mapping the clinical pathway for patients undergoing VS resection. At present there is no set standard for the use of process mapping for VS surgery. Given the high volume of VS resection cases at our unit, this study acts as an exemplar to show the utility of the process mapping methodology and can be emulated by other neurosurgical units. The amalgamation of a diverse range of stakeholder opinions allowed for the development of robust process maps.[21] Given that the management of VS patients often incorporates input from neurosurgeons, otorhinolaryngologists and additional healthcare professionals, other lateral skull base units can also utilise process mapping to identify the unique structure of their service and areas for development.[34] Furthermore, process mapping can also be utilised to identify areas of service delay as well as points for patients education and recruitment to potential clinical trials.

Findings in the context of the literature

The success of process mapping is evident within neurosurgery, proving useful in spinal surgery and external ventricular drain placement.[35–38] Within VS surgery, process mapping has also been utilised in another UK neurosurgical centre, in an effort to improve services by identifying bottlenecks, as well as undertaking demand and capacity studies.[37] In addition, Yawn et al. has shown that multidisciplinary team designed process maps of the VS resection pathway has significantly reduces the length of ICU stay from 2.1 days to 1.6 days ($p = 0.02$).[38] Our study also utilises the multidisciplinary team in process map construction.[35–38] However, as with Hanrahan et al. the use of a two-staged methodology remains unique to our study.[12] Stakeholder interviews followed by EHR validation allows for the creation of robust process maps, better representing the true patient experience. The use of this quantitative methodology also increases certainty for the correct identification of critical data entry points.

Our process maps have also helped highlight areas for improved documentation. Clear and detailed documentation is vital when managing patients undergoing VS resection, given the wide range of stakeholders involved in providing care. Poor, inaccurate and unstructured documentation invariably has a negative impact, not only on patient care but on research and quality improvement.[39–41] Furthermore, as transparency increases with patients having greater access to their clinical information, it is vital that care is taken in inputting accurate information.[42–44] Structured data entry offers a solution to improving documentation. Ebber et al. reported independent reviewers measuring documentation quality, scoring structured notes significantly higher than free-text entries.[45–47]

Utilising structured data entry at critical patient pathway points can help optimise the quality of data points that can be extracted for research and audit purposes.[12] Our study has taken the first step in identifying areas for structured data entry and extraction in the preoperative, inpatient and follow-up settings for patients with VS. The roadmap towards automated data collection will include the production of a core dataset of variables related to VS resection, followed by structured data entry and behavioural interventions to prompt stakeholders adherence to the required data entry practices.[12] In VS surgery, data extraction variables may range from simple data points such as age and length of stay, to more complex data including facial nerve palsy and CSF leak.[12,48] Complex data points may also include quality of life (QoL) measures such as reduced energy and anxiety all of which are strongest predictors of both physical and mental QoL outcomes in VS patients.[49] Furthermore, the use of automated data collection in neurosurgery remains within its infancy, with significant progress required prior to implementation in clinical practice.[12] However, early promise is already evident, such as Williams et al. which shows the successful employment of a natural language processing (NLP) platform in extracting concepts relating to VS from patient notes.[12,50,51] Further improvements in both NLP technology and documentation will enhance the quality of data extracted, benefiting audit, research and patient care.

This study presents a single centre experience of process mapping for patients undergoing primary VS resection. This methodology has the potential to be replicated by other centres with lateral skull base services to aid in the identification of their own unique critical data entry points, helping implement change and improve the care provided.[12,52] Moreover, the combination of process maps across multiple units, can allow centres to improve their services based on a mixture of experiences, with the potential to move towards a national standardised care pathway for VS patient management.[53]

Strengths and limitations

A broad spectrum of stakeholders were interviewed in an effort to ensure all perspectives in the management of VS patients were considered and any biases in stakeholder perspectives were mitigated for when designing the process maps. In addition, given our unit has senior input from multiple consultant neurosurgeons and otorhinolaryngologists, this allowed us to construct process maps based on the vast combined and varied experiences of these clinicians. Process maps were also subsequently validated against EHR increasing the likelihood of the constructed maps reflecting the true clinical pathway for VS patients.

A key limitation within this study, is the findings are representative of a single centre, as well as the exclusion of private patients and those who have undergone Gamma Knife surgery from the data analysed. Although focusing on only VS resection cases allows for the creation of specific process maps, this limits the external validity of the study. In addition, as our centre is not a national hub for NF2 patients, this relevant patient cohort is not represented within our work. Future versions of VS process maps should aim to incorporate these additional factors. Furthermore, key stakeholders may have been missed during the purposive snowball process due to selection bias among authors and stakeholders interviewed.

CONCLUSION

This is the first use of a two-staged mixed methodology for process mapping patients undergoing VS resection. Our study was able to identify key areas for documentation improvement and critical data entry points within the preoperative, inpatient, and postoperative pathways. These data entry points can be targeted for structured data entry, enhancing quality improvement and harbouring the potential for future automated data collection. The methodology used within this study can be repeated in other skull base centre in an effort to strive towards optimal care for VS patients nationally.

STATEMENT AND DECLARATION

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Author contributions: SS, SCW, JGH, WRM, JB, NN, HJM and PG contributed to conceptualisation and design of the study. SS and SCW contributed to data extraction, curation, and analysis. SS also contributed to project administration. JGH, WRM, SK, NK, RO, SRS, HJM and PG provided supervision of the study. All authors were involved in the writing, reviewing and approval of the final version of the manuscript.

Conflicts of interest/Competing interests: The authors have no conflict of interest, relevant financial or non-financial interests to disclose.

Ethics Approval: This study was approved and registered locally as a service evaluation project and had no bearing on patient management with no identifiable patient data presented. Therefore, no patient consent or approval from the institutional review board (IRB)/ethics committee was required. Stakeholders involved, gave written informed consent to participate within the study.

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FIGURE LEGENDS

Figure 1: Study flow diagram for process map development.

Figure 2: Process map depicting pathway from presentation to health care services through to operation. Solid lines represent pathways must occur and dashed lines represent multiple options. Colour codes indicate % of presence of documentation in real-world cohort data, with 100%, 90 – 99%, 80 – 89% and <80%.

Figure 3: Process map depicting pathway from operation through to discharge from hospital. Solid lines represent pathways must occur and dashed lines represent multiple options. Colour codes indicate % of presence of documentation in real-world cohort data, with 100%, 90 – 99%, 80 – 89% and <80%.

Figure 4: Process map depicting the outpatient pathways following vestibular schwannoma resection. Solid lines represent pathways must occur and dashed lines represent multiple options. Colour codes indicate % of presence of documentation in real-world cohort data, with 100%, 90 – 99%, 80 – 89% and <80%.

TABLE LEGEND

Table 1: Stakeholder background and characteristics, IOR= interquartile range

Table 2: Patient demographics table.

Speciality (N = 20)	
Neurosurgery	10 (50%)
Otorhinolaryngology	6 (30%)
Anaesthesia and Neuro-critical Care	1 (5%)
Neuropathology	1 (5%)
Oncology	1 (5%)
Radiology	1 (5%)
Stakeholder position (N = 20)	
Professor/Consultant	9 (45%)
Senior Trainee	3 (15%)
Junior Trainee	3 (15%)
Therapy Team Member	3 (15%)
Clinical Nurse Specialist	1 (5%)
Multidisciplinary Team Coordinator	1 (5%)
Experience in managing vestibular schwannoma resection	
Combined total experience in years	149
Median in years (IQR)	3 (1 – 12.5)
Questionnaire response median score (IQR)	
I am routinely involved in the patient pathway of vestibular schwannoma patients undergoing surgery	4.5 (4 – 5)
I am directly involved in the patient pathway prior to admission for surgery	4 (1.75 – 4)
I am directly involved in the patient pathway during their inpatient stay for surgery	5 (4 – 5)
I am directly involved in the patient pathway in the outpatient setting after they have undergone surgery	4 (2 – 4.25)

Table 1: Stakeholder background and characteristics, IOR= interquartile range

Variables (N = 50)	
Median age (IOR)	57.5 (45.5 – 65.75)
Gender ratio Male:Female	29:21 (58%, 42%)
Median length of stay (IOR)	8 days (6 – 11)
Presenting symptoms (N = 50)	
Hearing loss	34 (68%)
Gait abnormality	22 (44%)
Sensory disturbance	11 (22%)
Tinnitus	11 (22%)
Vertigo	8 (16%)
Headache	8 (16%)
Facial weakness	5 (10%)
Pain/Trigeminal neuralgia	3 (6%)
Nausea/vomiting	3 (6%)
Progressed residual	3 (6%)
Dysphagia	2 (4%)
Hydrocephalus	1 (2%)
Visual problems	1 (2%)
Operative approach (N = 50)	
Retrosigmoid approach	27 (54%)
Translabyrinthine approach	22 (44%)
Transotic approach	1 (2%)

Table 2: Patient demographics table.

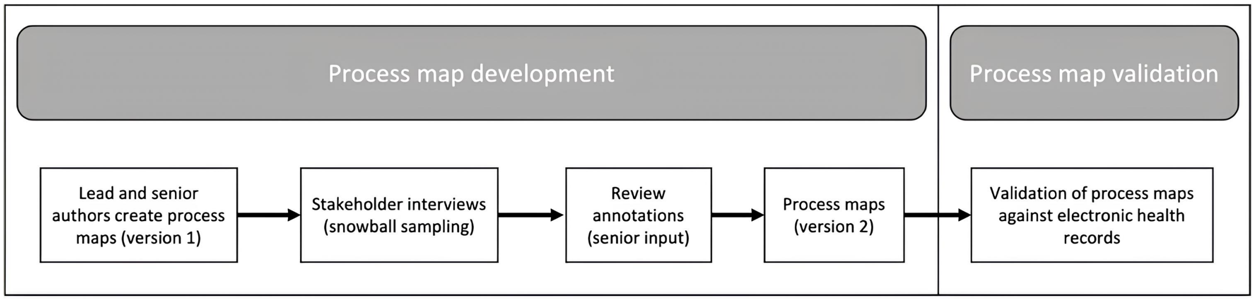
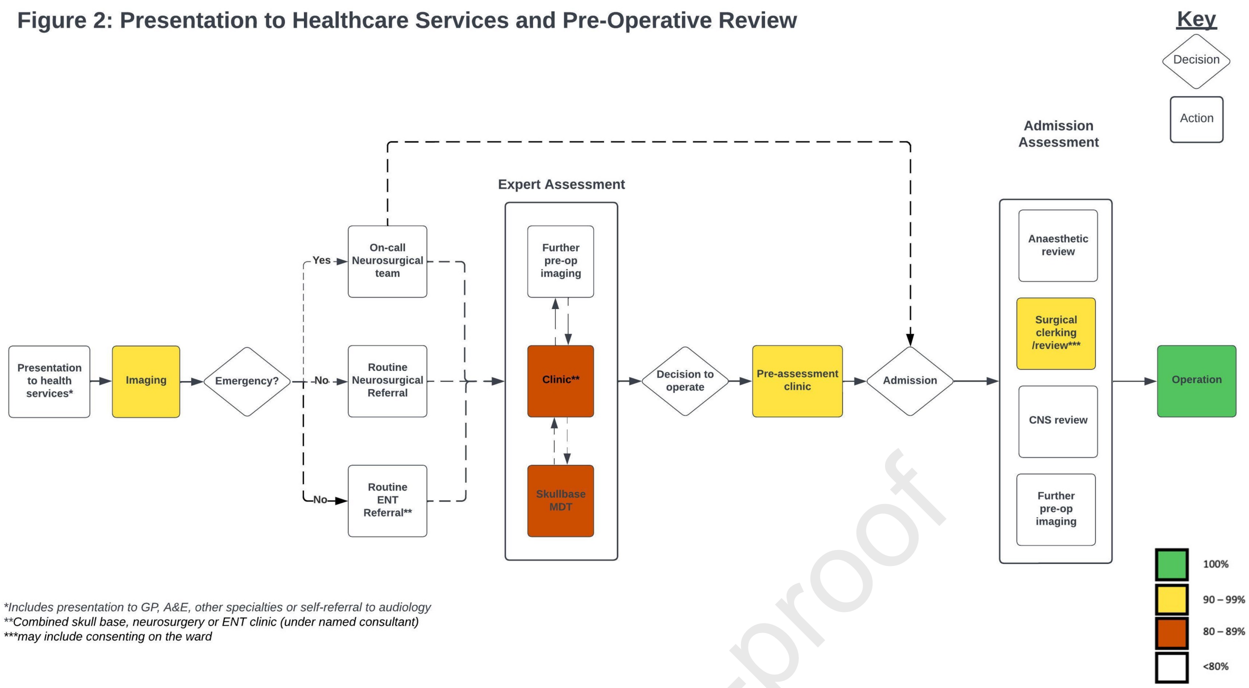
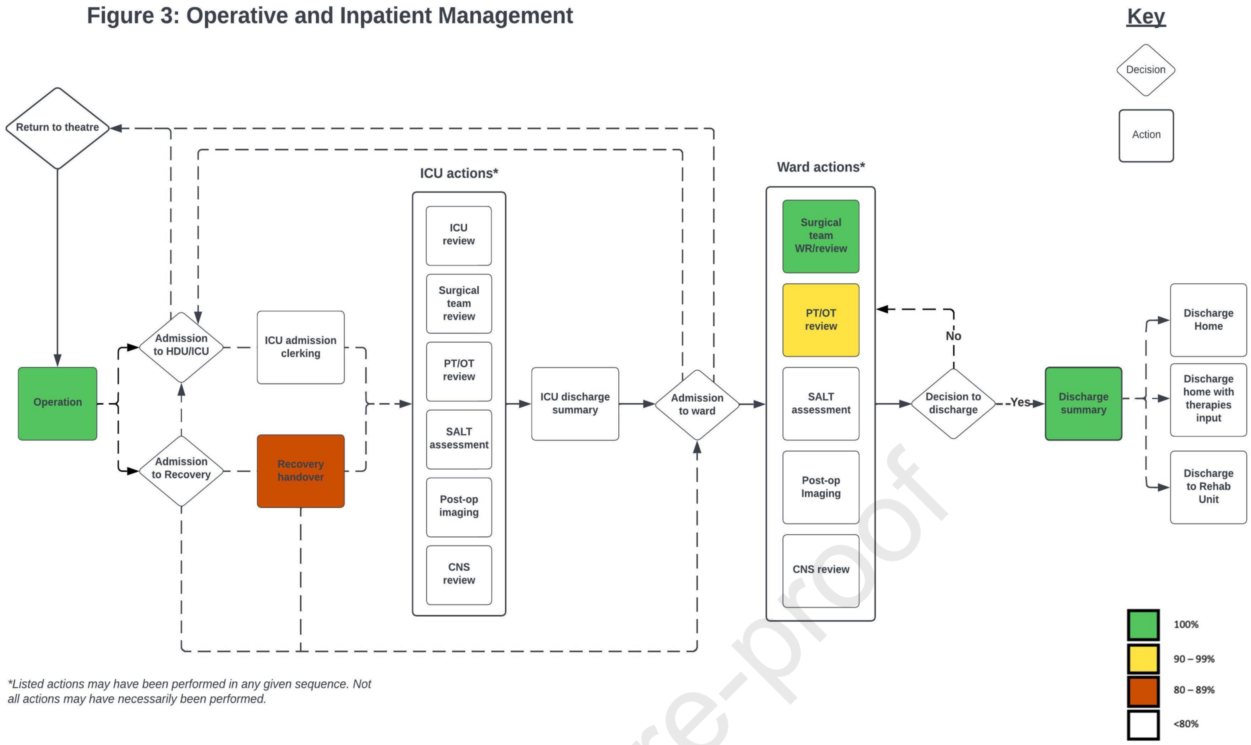

Process map development
Process map validation
Lead and senior authors create process maps (version 1)
Stakeholder interviews (snowball sampling)
Review annotations (senior input)
Process maps (version 2)
Validation of process maps against electronic health records

Figure 2: Presentation to Healthcare Services and Pre-Operative Review



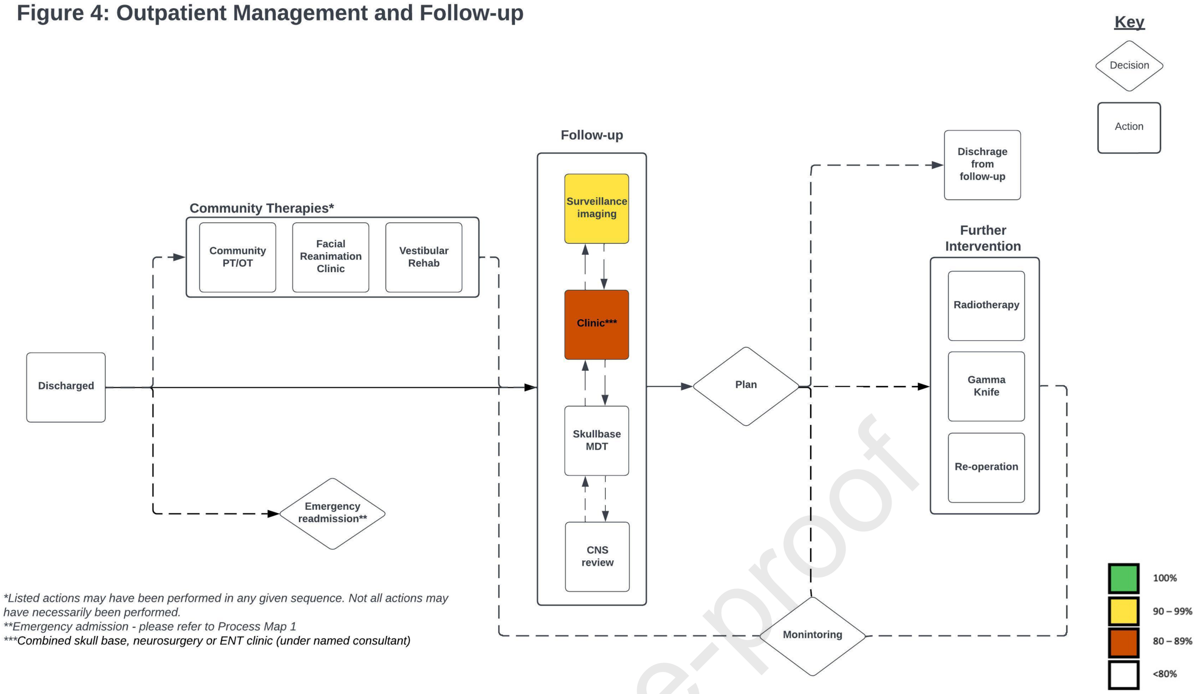
*Includes presentation to GP, A&E, other specialties or self-referral to audiology
**Combined skull base, neurosurgery or ENT clinic (under named consultant)
***may include consenting on the ward

Figure 3: Operative and Inpatient Management



*Listed actions may have been performed in any given sequence. Not all actions may have necessarily been performed.

Figure 4: Outpatient Management and Follow-up



**Listed actions may have been performed in any given sequence. Not all actions may have necessarily been performed.*
***Emergency admission - please refer to Process Map 1*
****Combined skull base, neurosurgery or ENT clinic (under named consultant)*

ABBREVIATIONS

CSF: cerebrospinal fluid

EHR: electronic health records

HDU: high dependency unit

ICU: intensive care unit

IRB: institutional review board

NLP: natural language processing

NF2: neurofibromatosis 2

QoL: quality of life

VS: vestibular schwannomas

STATEMENT AND DECLARATION

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Ethics Approval: This study was approved and registered locally as a service evaluation project and had no bearing on patient management with no identifiable patient data presented. Therefore, no patient consent or approval from the institutional review board (IRB)/ethics committee was required. Stakeholders involved, gave written informed consent to participate within the study.