**Title: Changes in attitudes towards telemedicine in acute burn care following the Covid-19 pandemic**

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**Background**

Telemedical referrals after burn injury had been shown to be advantageous over telephone referrals for multiple reasons, however there were several key barriers towards complete implementation. The Covid-19 pandemic facilitated the adoption of telemedicine to ensure the safety of both clinicians and patients. Due to the circumstances, it was unclear whether the pre-pandemic barriers still existed despite the complete implementation of telemedicine. This study aims to evaluate clinicians’ views about the barriers towards implementation of a specific telemedicine system for burns referrals, and their changing attitudes following the pandemic, to identify key domains for improvement in current and future telemedicine systems.

**Methods**

A questionnaire was created to evaluate the attitudes of referring clinicians towards telemedicine, following literature searches and administration of a pilot questionnaire. This was administered via telephone to staff working in EDs and MIUs which referred to the South-West United Kingdom Burns Network using the Medical Data Solutions and Services (MDSAS) system, in both 2019 and 2022. A statistical analysis was performed to compare the attitudes of clinicians towards telemedicine both pre- and post-pandemic.

**Results**

100 respondents completed the survey in 2019 and 70 in 2022, with similar demographics of respondents. Out of the twelve barriers identified, the lack of reliable Wi-Fi and need to duplicate notes were identified as the main obstacles to implementation in both time periods. In both years, the single greatest barrier reported was poor access to reliable Wi-Fi (p=0.944). Miscommunication between clinicians using the system, inadequate numbers of devices and financial constraints were identified less frequently as barriers in 2022 than 2019 (p=0.005, p=0.047 and p<0.001 respectively). However, significantly more respondents reported time pressures when waiting for a response to their telemedicine referral in 2022 (p=0.022).

**Conclusion**

Overall, clinicians displayed a positive attitude towards the MDSAS system for acute burns, with clinicians identifying fewer concerns with the system following the Covid-19 pandemic. However, concerns over the time pressures that this telemedicine system places on the referring clinician and existing Wi-Fi infrastructure persist. Further streamlining of the system and investment in internet access is recommended, with continued input from all stakeholders.

**Introduction**

Since its emergence in the 1980s, the use of telemedicine for the purposes of early diagnosis and follow up of burns has accelerated, largely due to the development of more accessible and secure methods of image and video transmission (1,2). Within the UK, Medical Data Solutions and Services (MDSAS) telemedicine referral system (<https://referrals.mdsas.com/>) for acute burns has been adopted by multiple Trusts and burn networks. Having first been piloted in Greater Manchester in 2017, it assists in acute burn referrals from Emergency Departments (EDs) or Minor Injuries Units (MIUs) to burn specialists. Developed in conjunction with NHS Digital, this burns telemedicine system utilizes a mobile application on any smartphone or tablet in conjunction with a web portal. The latter is accessed only through computers which are linked through the ‘NHS Spine’ network (3), which generates a unique Quick Response (QR) code for each patient which is scanned using the device app. Once scanned, images of the burn along with a referral form detailing the history, are sent in an encrypted manner to a cloud-based server and linked to the patient. The photographs are temporarily stored on the local device and cannot be accessed for any purpose other than by the MDSAS software; this satisfies the framework for the storage and transmission of confidential patient data within the UK [4]. The remote burns team can then access the images and history on the web portal, allowing a senior clinician to determine an appropriate management based upon the information provided.

Telemedical referrals have multiple advantages over traditional telephone referrals. Firstly, they decrease the necessity for face-to-face assessment, particularly for minor burns, and increase the proportion of day case, as opposed to inpatient, surgeries [5]. The system facilitates remote differentiation of the cases requiring inpatient versus day-case care [5], as the receiving clinician has increased confidence that their initial, remote diagnosis was accurate with the support of real-time images. In turn, there is increased patient satisfaction – specifically related to more locally delivered care - and less burden to the patient and NHS as inpatient stays and the number of unnecessary appointments are decreased [5-7]. Secondly, the accuracy and efficiency of photographs in capturing burns visually has been assessed in multiple studies, with 86% of clinicians reporting the ability to assess the burn size and 67% burn depth [3]. It has been demonstrated that evaluation via remote and in-person methods are highly comparable [2,8,9], thus enabling similar quality of care to face-to-face assessments. Finally, telemedicine offers the advantage of facilitating a multidisciplinary team (MDT) approach [10].

Although telemedicine has been proven beneficial for patients and clinicians, especially in rural areas where there is limited burn expertise, its implementation has been associated with several barriers. A study evaluating 1000 telemedicine follow-up appointments in the United States demonstrated that the three key hindrances were inadequate planning and development of infrastructure, confidentiality, and telemedicine regulation, such as the requirement to use specific, approved provider networks [7].

The Covid-19 pandemic accelerated the integration of telemedicine into wider emergency care, with the advantages of remote consultations quickly becoming apparent for the safety of clinicians and patients, and for the conservation of resources [11]. This systematic review also noted that despite a cost reduction with the use of telemedicine, technical, infrastructure and staff training issues remained a barrier to its widespread implementation. Moreover, it identified a scarcity of research examining clinicians’ experiences and satisfaction with telemedicine systems [12]. For most of the UK, the pathway for burn referrals changed little during the pandemic, given the previous adoption of the MDSAS system across two of the larger networks [13]. However, it was postulated that clinicians’ acceptance and ability to use the system was improved due to the wider adoption of telemedicine for acute referrals to other non-burn specialties. This study aims to identify the barriers limiting the adoption of a specific telemedicine referral services (MDSAS) for acute burns care in the United Kingdom, and to evaluate whether attitudes towards telemedicine have changed since the Covid-19 pandemic. Identification and comparison of these perceived barriers over time informs discussions about methods to facilitate further implementation and can highlight key areas for resource allocation.

**Methods**

*Questionnaire Development*

Literature about the attitudes of clinicians towards telemedicine in burn referrals and other hospital specialties, such as dermatology and psychiatry, was surveyed. A literature review was conducted using the databases Medline and EMBASE on Ovid and PubMed focusing on English-language publications, without date restriction. Boolean searches were undertaken using standard MeSH terms in combination, for example, <telemedicine> AND <attitudes of health professionals> AND <burns> AND <emergency>. Based upon these findings, preliminary domains were devised to categorize barriers to implementation, which formed the construct for the pilot questionnaire. The pilot consisted of open questions to gauge knowledge and personal perspectives about the barriers identified in the literature towards the general implementation of telemedicine. This was followed by a description of the MDSAS burns referral system where respondents were asked about potential barriers they perceived for this specific system. The pilot questionnaire was administered locally, in the emergency departments of Bristol Royal Infirmary, The Bristol Royal Hospital for Children, and Southmead Hospital - three hospitals that, at the inception of the study, did not utilize telemedicine for burn referrals to their local burn service. A total of 25 responses were obtained from a mixture of nursing and medical staff. The data from the pilot was collected and reviewed to further categorize and refine the barriers which might impede the implementation of telemedicine for referring patients.

Following assimilation of the pilot results, the final questionnaire was optimized in conjunction with a Social Science Research Fellow experienced in questionnaire design. It consisted of two general open-ended questions followed by twelve closed statements about specific, perceived barriers to implementation, for which the respondent had to express agreement or disagreement. They were then asked to identify the single, most significant barrier to telemedicine adoption from these statements.

*Questionnaire administration*

Both questionnaires (pre- and post-Covid) were administered over the telephone to medical and nursing staff working in EDs or MIUs which made referrals to the burn services of the South-West United Kingdom (SWUK) burn network.

The first questionnaire was administered during the 30th week of 2019. At that point, the MDSAS system had been operational in the SWUK burn network for one year. The second questionnaire was administered during the 27th and 28th weeks of 2022. The date of re-administration was determined at a time point that was well beyond the accepted final phase of the Covid pandemic within the UK, following lifting of all legal restrictions in England [14]. During both rounds of data collection, where possible, an attempt was made to gain a balanced representation of the workforce composition in acute settings by administering the questionnaire to multiple individuals within the same referring service.

*Statistical analysis*

The responses from 2019 and 2002 were compared to identify changes in the statements viewed as key barriers, and in the greatest barriers to implementation. Statistical analyses were conducted using SPSS – Statistics (SPSS; IBM, Chicago, IL, USA, version 28, 2021). Tests of association between categorical variables were assessed using the chi-square test. The strength of the association between binary variables was quantified using the odds ratio, and 95% confidence intervals were used to show the precision of estimated percentages.

**Results**

*Demographics*

100 respondents completed the survey in 2019, compared to 70 in 2022, with all ED and MIUs in the Southwest contacted for responses. Table 1 details the two cohorts. In both 2019 and 2022 18 EDs were identified across the South-West, with 55 MIUs in 2019 and 45 in 2022, due to several closures and mergers of units. Responses were obtained from at least 75% of these services across both time periods. Proportionately more nursing staff responded in the second survey, but this did not reach statistical significance (p=0.145). The respondents constituted 75% nurses and 25% doctors in 2019 compared to 84.3% nurses and 15.7% doctors in 2022. There was a significant variation in the number of years’ experience within ED of respondents between the two points of administration (p=0.002), with a far greater range in experience across the 2019 respondents. In 2022, most respondents (55.7%) had 0-5 years of experience, with no respondents having 26 years or more. There was no significant difference between time periods in the level of training of staff or the number of burns seen annually.

*Table 1: comparison of demographics of respondents between the two points of administration, 2019 and 2022. Year columns give the absolute number of respondents in each category with the percentage given in parentheses.*

|  |  |  |  |
| --- | --- | --- | --- |
| **Demographic** | **2019: N (%)** | **2022: N (%)** | **p-value** |
| **Occupation** | | | 0.145 |
| Nurse | 75 (75) | 59 (84.3) |
| Doctor | 25 (25) | 11 (15.7) |
| **Length of experience in MIU / ED (years)** | | | 0.002 |
| 0-5 | 28 (28) | 39 (55.7) |
| 6-10 | 21 (21) | 17 (24.3) |
| 11-15 | 19 (19) | 6 (8.6) |
| 16-20 | 13 (13) | 6 (8.6) |
| 21-25 | 13 (13) | 2 (2.9) |
| 26-30 | 4 (4) | 0 (0) |
| 30+ | 2 (2) | 0 (0) |
| **Level of training** | | | 0.233 |
| Band 5 | 4 (4) | 5 (7.1) |
| Band 6 | 27 (27) | 12 (17.1) |
| Band 7 | 34 (34) | 37 (52.9) |
| Band 8 | 3 (3) | 1 (1.4) |
| Paramedic | 7 (7) | 5 (7.1) |
| Foundation doctor | 4 (4) | 1 (1.4) |
| Registrar | 9 (9) | 5 (7.1) |
| Consultant | 12 (12) | 4 (5.7) |
| **Reported number of burns seen annually** | | | 0.391 |
| <100 | 42 (42) | 38 (54.3) |
| 100-199 | 29 (29) | 16 (22.9) |
| 200-299 | 16 (16) | 7 (10) |
| >300 | 13 (13) | 9 (12.9) |

*Qualitative experiences*

These were captured by the freeform response component of the questionnaire. A narrative analysis indicated that nearly all respondents had good knowledge of what the term *telemedicine* encompassed. They were aware that it frequently involved health care professionals in different specialties and locations sharing information remotely. Some were also aware of telemedicine outside of the referral environment, such as outpatient or GP appointments via video conferencing. Most explicitly referenced the MDSAS burn referral system as an example of telemedicine that they were well acquainted with, and described a generally positive experience, although a common theme was that there was the potential for further optimization of the system.

*Agreement with pre-defined statements about barriers to implementation of a telemedicine system*

In both 2019 and 2022, clinicians were asked to express their agreement or disagreement with twelve pre-defined statements relating to perceived barriers to the adoption of the MDSAS burns referral system (Table 2). Overall, across both time periods, the *lack of reliable Wi-Fi* (statement 6, 54.7% agreement) and *need to duplicate both paper and electronic notes* (statement 9, 54.7%) were identified as the main barriers to implementation. In 2019, the Wi-Fi issues were the top ranked impediment (59%), whilst in 2022 it was the duplication of notes (55.7%). The statements next most selected as a barrier were: *an inadequate number of devices in the department to deal with the extra burden of referring online* (statement 7, 47.6%); *too much reliance on the clinician’s ability to communicate via succinct messages for the system to be effective and efficient* (statement 4, 42.9%); *too much reliance on technology without reliable backup systems* (statement 5, 40.0%); and *difficulties with personal ability to use the technology* (statement 1, 39.4%).

Four of the twelve pre-defined barriers displayed a statistically significant difference between the response sets in 2019 and 2022. Three were associated with a reduction and one with an increase in their relative selection as an important barrier. *Miscommunication between clinicians* (statement 3) using the system warranted significantly less concern in 2022 than 2019 (21.4% vs 42.0% agreed with the statement respectively, p=0.005). Similarly, in 2022, significantly fewer respondents considered an *inadequate number of devices* (statement 7) to be a potential barrier (p= 0.047), and they were less concerned about the *financial implications of buying devices* t*o send telereferrals or system upkeep* (statement 12) (p<0.001) than in 2019. However, in 2019 only 20.0% of respondents considered *waiting for a response to their telemedicine referral to be a waste of time* (statement 8), but this significantly increased to 35.7% in 2022 (p=0.022).

*Table 2: comparison of attitudes about pre-defined barriers to implementation of a burn telemedicine system across ED and MIU departments in the South-West United Kingdom in questionnaires administered in 2019 and 2022. Disagreement/agreement columns give the absolute number of respondents in each category with the percentage given in parentheses.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Statement of possible barrier to implementation** | **Year** | **Disagree: N (%)** | **Agree: N (%)** | **P-value** |
| 1) Difficulties with your personal ability to use the technology. | 2019 | 58 (58.0) | 42 (42.0) |  |
| 2022 | 45 (64.3) | 25 (35.7) |
| **Total** | 103 (60.6) | 67 (39.4) | **0.409** |
| 2) The burn team that I am referring to always like to see the patients in person therefore sending photos or videos seems redundant. | 2019 | 91 (91.0) | 9(9.0) |  |
| 2022 | 62 (88.6) | 8 (11.4) |
| **Total** | 153 (90.0) | 17 (10.0) | **0.603** |
| 3) I am worried about miscommunication as there is not always a continuous conversation. | 2019 | 58 (58.0) | 42 (42.0) |  |
| 2022 | 55 (78.6) | 15 (21.4) |
| **Total** | 113 (66.5) | 57 (33.5) | **0.005** |
| 4) There is too much reliance on the clinician’s ability to communicate via succinct messages for the system to be effective and efficient. | 2019 | 53 (53.0) | 47 (47.0) |  |
| 2022 | 44 (62.9) | 26 (37.1) |
| **Total** | 97 (51.1) | 73 (42.9) | **0.201** |
| 5) There is too much reliance on technology without reliable backup systems. | 2019 | 63 (63.0) | 37 (37.0) |  |
| 2022 | 39 (55.7) | 31 (44.3) |
| **Total** | 102 (60.0) | 68 (40.0) | **0.340** |
| 6) There is poor access to reliable Wi-Fi for the newer systems to make it work efficiently. | 2019 | 41 (41.0) | 59 (59.0) |  |
| 2022 | 36 (51.4) | 34 (48.6) |
| **Total** | 77 (45.3) | 93 (54.7) | **0.179** |
| 7) There are an inadequate number of devices in our department to deal with the extra burden of referring online. | 2019 | 46 (46.0) | 54 (54.0) |  |
| 2022 | 43 (61.4) | 27 (38.6) |
| **Total** | 89 (52.4) | 81 (47.6) | **0.047** |
| 8) It is a waste of time having to wait for a response sent through telemedicine images. | 2019 | 80 (80.0) | 20 (20.0) |  |
| 2022 | 45 (64.3) | 25 (35.7) |
| **Total** | 125 (73.5) | 45 (26.5) | **0.022** |
| 9) I do not want to write both clinical notes and separate notes online for the telemedicine referral. | 2019 | 46 (46.0) | 54 (54.0) |  |
| 2022 | 31 (44.3) | 39 (55.7) |
| **Total** | 77 (45.3) | 93 (54.7) | **0.825** |
| 10) I am worried about the constant training required due to the high turnover of doctors and nurses within our department. | 2019 | 80 (80.0) | 20 (20.0) |  |
| 2022 | 55 (78.6) | 15 (21.4) |
| **Total** | 135 (79.4) | 35 (20.6) | **0.821** |
| 11) I am worried about the security of data and the danger of improper sharing of information. | 2019 | 66 (66.0) | 34 (34.0) |  |
| 2022 | 54 (77.1) | 16 (22.9) |
| **Total** | 120 (70.6) | 50 (29.4) | **0.117** |
| 12) I am concerned about the financial costs associated with buying devices to send telereferrals or the upkeep of the system. | 2019 | 69 (69.0) | 31 (31.0) |  |
| 2022 | 67 (95.7) | 3 (4.3) |
| **Total** | 136 (80.0) | 34 (20.0) | **<0.001** |

*Single most important barrier to implementation of a telemedicine system*

In the second part of the questionnaire, respondents were asked to select their *single, greatest perceived barrier to telemedicine system implementation* (Table 3 and Figure 1). In both years, *poor access to reliable Wi-Fi* (statement 6) was rated as the greatest perceived barrier, with no significant difference in its ranking between the two time periods (p=0.944). Concerns about the *inadequate numbers of devices within the department* (statement 7) and the need for *duplication of notes for the referral* (statement 9) were identified as the most concerning barrier by the next highest numbers of clinicians. The proportion of clinicians identifying these two statements as their greatest concerns increased in 2022 compared to 2019, however the changes between the years were not significant (p=0.453 and p=0.575, respectively).

It was also noted that there was a statistically significant drop in *financial costs* (statement 12) being ranked as the top barrier to implementation of a burn telemedicine system (11% in 2019 vs 0% in 2022, p=0.004), whilst there was also a statistically significant increase in the number of clinicians considering the excessive *reliance on the clinician’s ability to communicate succinctly to the referral team* (statement 4) as the greatest issue (1% in 2019 vs 7.1% in 2022, p=0.033).

In both years, there were a small minority of respondents who chose an alternative barrier to implementation that was not one of the twelve in the pre-defined list. This was detailed as “*other*” and is detailed in the last row of Table 3. It did not change in terms of the proportion of respondents who selected it across both time periods (p= 0.838). Barriers to implementation volunteered in this category included issues with patient consent, appropriate IT support, resistance to change in the clinical environment, and difficulties with communication between care-giving organizations.

*Table 3: comparison of the pre-selected barrier statements to the implementation of a burn telemedicine system across ED and MIU departments in the South West UK, ranked by each respondent as the single, greatest perceived barrier to system implementation in the 2019 and 2022 questionnaires. Year columns give the absolute number of respondents in each category with the percentage given in parentheses. The ‘other’ category in the last row were barriers to implementation that were volunteered as the most pre-eminent by a given respondent but were not one of the pre-selected list.*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Statement** | **Year** | **Disagree: N (%)** | **Agree: N (%)** | **P-value** |
| 1) Difficulties with your personal ability to use the technology. | 2019 | 96 (96.0) | 4 (4.0) |  |
| 2022 | 64 (91.4) | 6 (8.6) |
| **Total** | 160 (94.1) | 10 (5.9) | **0.213** |
| 2) The burn team that I am referring to always like to see the patients in person therefore sending photos or videos seems redundant. | 2019 | 97 (97.0) | 3 (3.0) |  |
| 2022 | 70 (100) | 0 (0.0) |
| **Total** | 167 (98.2) | 3 (1.8) | **0.144** |
| 3) I am worried about miscommunication as there is not always a continuous conversation. | 2019 | 94 (94.0) | 6 (6.0) |  |
| 2022 | 68 (97.1) | 2 (2.9) |
| **Total** | 162 (95.3) | 8 (4.7) | **0.341** |
| 4) There is too much reliance on the clinician’s ability to communicate via succinct messages for the system to be effective and efficient. | 2019 | 99 (99.0) | 1 (1.0) |  |
| 2022 | 65 (92.9) | 5 (7.1) |
| **Total** | 164 (96.5) | 6 (3.5) | **0.033** |
| 5) There is too much reliance on technology without reliable backup systems. | 2019 | 95 (95.0) | 5 (5.0) |  |
| 2022 | 66 (94.3) | 4 (5.7) |
| **Total** | 161 (94.7) | 9 (5.3) | **0.838** |
| 6) There is poor access to reliable Wi-Fi for the newer systems to make it work efficiently. | 2019 | 81 (81.0) | 19 (19.0) |  |
| 2022 | 57 (81.4) | 13 (18.6) |
| **Total** | 138 (81.2) | 32 (18.8) | **0.944** |
| 7) There are an inadequate number of devices in our department to deal with the extra burden of referring online. | 2019 | 87 (87.0) | 13 (13.0) |  |
| 2022 | 58 (82.9) | 12 (17.1) |
| **Total** | 145 (85.3) | 25 (14.7) | **0.453** |
| 8) It is a waste of time having to wait for a response sent through telemedicine images. | 2019 | 91 (91.0) | 9 (9.0) |  |
| 2022 | 63 (90.0) | 7 (10.0) |
| **Total** | 154 (90.6) | 16 (9.4) | **0.826** |
| 9) I do not want to write both clinical notes and separate notes online for the telemedicine referral. | 2019 | 86 (86.0) | 14 (14.0) |  |
| 2022 | 58 (82.9) | 12 (17.1) |
| **Total** | 144 (84.7) | 26 (15.3) | **0.575** |
| 10) I am worried about the constant training required due to the high turnover of doctors and nurses within our department. | 2019 | 94 (94.0) | 6 (6.0) |  |
| 2022 | 69 (98.6) | 1 (1.4) |  |
| **Total** | 163 (95.9) | 7 (4.1) | **0.14** |
| 11) I am worried about the security of data and the danger of improper sharing of information. | 2019 | 96 (96.0) | 4 (4.0) |  |
| 2022 | 66 (94.3) | 4 (5.7) |  |
| **Total** | 162 (95.3) | 8 (4.7) | **0.603** |
| 12) I am concerned about the financial costs associated with buying devices to send telereferrals or the upkeep of the system. | 2019 | 89 (89.0) | 11 (11.0) |  |
| 2022 | 70 (100) | 0 (0.0) |  |
| **Total** | 159 (93.5) | 11 (6.5) | **0.004** |
| Other statement described as the clinicians highest perceived barrier to implementation | 2019 | 95 (95.0) | 5 (5.0) |  |
| 2022 | 66 (94.3) | 4 (5.7) |  |
| Total | 161 (94.7) | 9 (5.3) | **0.838** |

*Figure 1: bar chart depicting the statements perceived to be the greatest barriers to burns telemedicine system implementation across the South-West United Kingdom in 2019 and 2022, in terms of the percentage of clinicians which ranked a given statement as the single, greatest perceived barrier.* Chart, bar chart

Description automatically generated

**Discussion**

There were few disciplines in medicine which were unaffected by the measures implemented to counter the Covid-19 pandemic. Burn care was no exception. This included a change in the assessment of patients to a model based on remote advice and management within the community; in a well-resourced country such as the UK, telemedicine was central to this response [15]. In 2018, the SWUK burn network, one of the largest of the four networks within the UK, initiated the roll out of the MDSAS telereferral system, prior to the requirement for telemedicine within burn care set out in ‘The National Burn Care Standards’ in November 2019 [16]. Therefore, whilst a telemedicine system for referrals was established prior to the pandemic, at that point it was not a mandatory requirement for referral. Anecdotally, there was resistance to its uptake, with telephone referrals still being made. This prompted the first survey of this study in 2019 - to investigate the barriers towards the uptake of telemedicine within this setting. Shortly after the data collection, the Covid-19 pandemic arose and with it the imperative to minimise face-to-face contact. This increased the need to offer care at the initial point of contact guided by remote, expert advice. It did not change the mechanism of burn referrals across the SWUK network as the MDSAS system was already established [17]; rather MDSAS became the network-endorsed portal for referrals across the region. Due to this rapid push to utilise telemedicine, the authors were keen to investigate whether referring clinicians had changed their attitudes to the system through mandatory usage at the time of the pandemic.

Key domains identified using a comprehensive literature search were diverse and included those related to *infrastructure* (*e.g.* access to WiFi or financial cost), *process* (*e.g.* extra time required to create a referral or handling data security), and *general attitudes* (*e.g.* being adept with technology or suspicious of telemedicine’s utility) [17-20]. A questionnaire was developed and piloted across three ED and MIU sites with no telemedicine experience to probe the potential barriers to telemedicine implementation. This honed the specific barriers to the twelve detailed in the final questionnaire (first column of tables 2 and 3) which encompassed most of the reasons detailed by these respondents. Additionally, a free response in the final questionnaire permitted 'other’ barriers to be identified which were not covered by the twelve pre-selected options. As a confirmatory step, as well as the respondents being asked to identify their agreement or disagreement with the twelve pre-defined statements (Table 2), they were also asked to identify their single, most pre-eminent barrier (Table 3). There was good concordance between the two approaches.

The background of the respondents was similar across both time periods, with the majority being of a nursing background (mean 79.7%), with similar levels of training and annual exposure to burns. Nurses comprise the majority of staff of MIUs across the SWUK region. Additionally, there are more MIUs compared to EDs in the SWUK region, making the respondents representative of the care providers in this region. It was notable that most of the respondents reported seeing relatively large numbers of burns (>100/annum for a mean 51.9% across both time periods). The only significant demographic trend (p<0.002) between the two cohorts was the reduction in relative emergency department experience between 2019 and 2022; in the latter, there was a marked reduction in staff with more than 26 years’ experience. This could be for many reasons. One of which could be more senior staff stepping back from frontline duties due to either a perceived greater susceptibility to Covid-19 or an increased rate of anxiety, depression and burnout, linked to their seniority and increased responsibility, during the pandemic [21].

With regards to agreement or disagreement with the pre-defined statements about barriers to implementation of telemedicine, most (mean of 54.7% across both time periods) concurred that a *lack of reliable WiFi* and the *duplication of paper and electronic notes* were the most important factors, with no significant change between 2019 and 2022. This was mirrored by the answers when the respondents were asked to rank the most pre-eminent barrier. These results are in keeping with a recent systematic review of telehealth in burns, where unstable connections to telehealth platforms were identified as a key challenge within its 36 studies [22]. Reliable WiFi is a pre-requisite for using the MDSAS system as the clinicians’ personal device is used for taking photographs of the burn which is then transmitted to the cloud server. For MDSAS, in keeping with other telemedicine systems, the local record of the history must be supplemented with the same information within the electronic referral. This clearly creates extra work for the referrer as opposed to the traditional paper medical record and subsequent telephone call to a burn service. Therefore, in terms of the adoption of similar systems, an efficient WiFi network would appear to be paramount and for the electronic referral, emphasis on a minimum data set, relating the history and assessment, would appear to encourage usage.

As noted previously [7], infrastructure, demonstrated as *an inadequate number of devices within the department* (statement 7), was indicated as the next most concerning barrier. In practice, given that personal phones with cameras are increasingly ubiquitous, this is more likely to relate to NHS computers for entering the patient history. Therefore, a core minimum of available PC’s connected to the NHS network would be a pre-requisite to establishing a telemedicine system. Several of the other most frequently cited barriers would be easily surmounted by rigorous education about the system including: a personal ability to use technology (statement 1), concerns about data backup (statement 5 - reassuringly, the MDSAS system has a dual mirroring of data which can be accessed retrospectively), and miscommunication (statement 3) due to a temporal gap between the referral being sent and the decision being given by a burn service. Many of these concerns become less pressing after the Covid-19 period, with items such as miscommunication, number of devices and financial concerns dropping statistically in terms of relative significance. The latter is particularly notable as the MDSAS has few set-up costs and is free to use, so it is reassuring that this seems to have been more widely acknowledged.

Conversely, one barrier that increased in its relative importance during the pandemic was the *waste of time having to wait for a response sent through telemedicine images* (20% in 2019, 35.7% in 2022; p=0.022). The lack of immediate feedback, which was previously available with telephone referrals, is perceived as being a hindrance to progression. This issue is hard to surmount without the receiving burn service being constantly vigilant to new electronic referrals and/or the referrer chasing with an immediate phone call (stipulated as essential by the MDSA system), albeit this resulting in adding extra work. Another feasible way of increasingly the responsiveness of the receiving service is to trigger the system to send an automated email every time a new referral is received. The software can be set to do this, but again, it relies on the receiving clinician reviewing their emails on a regular basis. An unexpected finding was how relatively low the issues of data security (statement 11) rank in the approaches detailed in both tables 2 and 3. Equally, patient consent was only detailed once in ‘other’ potential barriers to a telemedicine system. Contrary to previous work [7], it seems that the NHS staff in this study are relatively trusting with regards to the information governance issues surrounding telemedicine referrals.

Although this study has focussed on conditions specific to the MDSAS, there are overarching considerations that can be translated to other telemedicine systems, as highlighted in a recent systematic review exploring the challenges of using telemedicine in burn management [22]. MDSAS has managed to address several barriers, such as inadequate number of devices, potential miscommunication between the referring and accepting parties and concerns over financial outlay. The lessons from this setting could be transposed to new systems. ‘Inadequate devices’ within a department has been surmounted by the usage of one’s own, personal digital device to relay images in a secure, encrypted manner. The barrier of miscommunication of clinical information [17], was found to be less pressing after Covid-19. This could potentially be due to increased familiarity and usage of the system resulting in improved confidence about the fidelity of information transfer on to a receiving unit. Consequently, an enhanced training period with experience of making trial referrals might encourage confidence to improve the adoption of future telemedicine systems. Finally, allowing the system to be free to use relieved the potential financial burden of both set up and maintenance costs. It would be prudent for future systems to place minimal financial burden on the referring services. However, there were a few factors highlighted in both years which remained barriers. The lack of reliable Wi-Fi is not unique to the MDSAS system and has been highlighted for other telemedicine systems [10, 23, 24, 25]. Therefore, the ability for existing networks to support the increased demand arising from telemedicine systems should be considered upon implementation. Lastly, the duplication of electronic notes and wait time for responses were two barriers which were still present in 2022. The former could be overcome in new systems through the integration of the referral system to existing documenting systems, so eliminating the need for duplication. The latter could be imaginatively addressed by the receiving team being alerted to new referrals in real time – perhaps by text messaging or equivalent - to increase responsiveness. With several of these concerns also confirmed by other groups [22], these findings are applicable more globally to the implementation of telemedicine within burns networks across developed healthcare systems.

*Limitations*

The SWUK burn network accepts referrals from many more MIUs than EDs. The former are predominantly in a more rural setting and are run by experienced nursing staff who may have variable exposure to telemedicine systems and theoretically less dedicated teaching about their usage. Rural MIUs may be more amenable to telemedicine referrals out of necessity for safe care from remote, expert providers, with more patient satisfaction if care can be provided locally [26]. Consequently, the findings of this study may not extrapolate fully to the opinion of urban EDs which have a greater contingent of medical staff. Moreover, this study cannot assess the influence of background factors other than the Covid-19 pandemic [11] which might have changed opinions about telemedicine with time. For example, there might have been greater acceptance of the MDSAS system purely through the effects of habituation. However, the findings of this study echo those of other groups within the SWUK network who found that the same system had a marked effect with an improvement in care [17]. Finally, the South-West UK region may have differing burn injury epidemiology, aetiology and referral pathways to other developed world settings, so care should be taken in extrapolation of these results to similar settings. However, many of our findings, regarding both benefits and potential improvements for telemedicine systems, remain consistent with similar themes identified in other regions utilizing telemedicine for a variety of specialist opinions [5,12].

**Conclusions**

Overall, across the SWUK burn network, clinicians displayed a positive attitude towards the MDSAS telemedicine system, finding it an efficient tool for acute burn referrals. This has only improved with the increased experience in telemedicine through the imperatives of the Covid-19 pandemic, particularly in relation to spheres such as the miscommunication of information, access to devices to make a referral, and the fiscal impact of setting up and running the system. However, there continue to be concerns over the time pressures that this specific telemedicine system places upon the referring clinician and the quality of existing Wi-Fi infrastructure. This study identifies several key domains which can be targeted in relation to resource allocation for the adoption of future telemedicine systems for burn injuries.

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