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Healthcare professionals' knowledge and attitudes towards surgical site infection and surveillance: A quasi-experimental study

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Abstract

Aim: SSI is one of the most prevalent healthcare-associated infections and is associated with extended hospital stays, increased need for reoperation and higher hospital readmission rates. Implementing systematic SSI surveillance can reduce these adverse outcomes. Implementing a surveillance system into a hospital is a complex intervention requiring that staff involved in a patient's perioperative journey have the knowledge of SSI prevention, the data required for surveillance, an understanding of how data informs quality improvement initiatives and their role in surveillance. The aim of this study was to evaluate the impact of a complex intervention on the knowledge and attitudes of healthcare professionals towards surgical site infection (SSI), SSI prevention and surveillance in a university hospital setting.

Design: The study used a quasi-experimental pre-test–post-test design.

Method: The impact of a complex intervention was evaluated by measuring healthcare professionals' ($n = 74$) knowledge of and attitudes towards SSI and surveillance. Normalisation process theory (NPT) guided the study and the development of the intervention.

Results: There was a statistically significant increase in scores on the knowledge of SSI and prevention from pre-intervention to post-test. The knowledge of risk factors scores at post-test was significantly higher than that at pre-intervention. Overall attitudes to SSI prevention and surveillance were good both pre-intervention and post-test but there was a significant change in the attitude of participants. The findings reveal an overall positive impact of the complex intervention on the knowledge and attitude of healthcare professionals relating to SSI, SSI prevention and surveillance; however, the extent of the change varied across items measured.

KEYWORDS
attitudes, health risks, healthcare worker, infection control, intervention, knowledge, multiprofessional education, patient surveillance, quality improvement, surgery

1 | INTRODUCTION

Surgical site infections (SSIs) are one of the most prevalent healthcare-associated infections (HAIs) and are associated with extended hospital stays, increased need for reoperation and higher hospital readmission rates (Badia et al., 2017). The European Centre for Disease Control (ECDC) defines an SSI as a wound infection that occurs after an invasive procedure. SSIs are classified as superficial incisional, deep incisional or organ space infections, which occur within 30 days of surgery or 90 days in surgeries where an implant was placed (European Centre for Disease Prevention and Control, 2017). The ECDC point prevalence survey of HAIs and antimicrobial use in European acute care hospitals in 2017 reported that the European SSI prevalence rate was 18.4%, which showed little change from the 2012 rate of 18.9% (Suetens et al., 2018; Zarb et al., 2012). The SSI rates across Europe vary, with an overall SSI rate of 16.9% in Belgium, 18.1% in Ireland and 29% in Switzerland (Health Protection Surveillance Centre, 2018; Vandael et al., 2020; Zingg et al., 2019). Patients undergoing colorectal surgery often report higher than usual rates of SSI ranging from 17.9% to 30% (Hübner et al., 2011; Kwaan et al., 2013). An retrospective audit, in 2018 at the university hospital where the author worked, reported an SSI rate of 25.3% in the elective colorectal surgery patients, which was a key driver for the introduction of a complex intervention to reduce the SSI incidence as reported in this paper (Horgan et al., 2023).

A study from the United States of America (USA) found that 55% of SSIs are avoidable when evidence-based prevention strategies are implemented (Umscheid et al., 2011). The ECDC and World Health Organization recommend SSI surveillance as a means to prevent the SSI and provide evidence-based recommendations to assist organisations to reduce SSI incidence rates (Allegranzi et al., 2016; European Centre for Disease Prevention and Control, 2017). The Health Protection Surveillance Centre, the specialist agency for surveillance in Ireland, also recommends systematic SSI surveillance systems in hospitals (Health Protection Surveillance Centre, 2021). Surveillance aims to monitor SSIs providing multidisciplinary teams with timely data to inform local quality improvement initiatives to reduce the rate of SSIs (Gillespie et al., 2015).

International policy documents highlight that it is imperative that healthcare professionals are aware of risk factors associated with the development of SSIs and strategies used to prevent SSIs (Baker et al., 2015; Suetens et al., 2018; Umscheid et al., 2011). However, inadequate knowledge of SSI prevention guidelines among healthcare professionals (HCPs) has been identified in many studies as one of the main causes of SSI (Woldegioris et al., 2019; Zucco et al., 2019). It has also been reported that surgeons and nurses have varying levels of knowledge and attitudes towards SSI prevention guidelines (Sartelli et al., 2018; Zucco et al., 2019). Physicians often have difficulty in correctly classifying SSIs (Sartelli et al., 2018; Troughton et al., 2019). Nurses were also identified as lacking knowledge and awareness of SSI (Labeau et al., 2010; Qasem & Hweidi, 2017; Woldegioris et al., 2019).

Complex interventions which include an educational component to address the knowledge deficit of healthcare professionals are key to improving the levels of knowledge (Baker et al., 2015; Mauger et al., 2014; Qasem & Hweidi, 2017). Whilst education and training is noted to be critical in the prevention of SSI, other factors such as resources, evidence-based guidelines, involvement of multidisciplinary team, audit, feedback and implementation of quality improvement measures have also been identified as being important in complex healthcare settings (Eskicioglu et al., 2012; Troughton et al., 2019).

Operationalising SSI guidelines are complex interventions and translating guidelines into routine healthcare practice is a challenge (Abbas & Pittet, 2016; Agreli et al., 2019; Hegarty et al., 2019; Murray et al., 2010). The term 'complex intervention' refers to interventions with numerous related parts such as a set of new systems and processes or new behavioural and working practices (Craig et al., 2013). The introduction of structured SSI prevention and surveillance systems are complex multicomponent interventions that require a collaborative systematic approach to building knowledge, analysing data and engagement in continuous quality improvements (Allegranzi et al., 2016; Bataille et al., 2021; Eskicioglu et al., 2012).

The key drivers for this study include the need to reduce SSI rates and recent evidence on the effectiveness of care bundles and surveillance on SSI rates (Bataille et al., 2021; Weiser et al., 2018). The research was undertaken in a large university teaching hospital where it was identified that a systematic evidence based approach to education on SSI, SSI prevention and surveillance was required. Therefore, this study aims to describe the effect of the implementation of SSI surveillance as a complex intervention on the knowledge and attitudes of HCPs towards SSI, SSI prevention and surveillance in a hospital setting.

2 | METHODS

2.1 | Design

This study used a one group pre-test and post-test quasi-experimental design. As this study was part of a larger quality improvement initiative, it adhered to the Standards for QUality Improvement Reporting Excellence (SQUIRE 2.0) (Ogrinc et al., 2015).

2.2 | Initiation, surveillance, sharing, improvements and plan for future (ISSIP) intervention

The framework of NPT and its key constructs (coherence, cognitive participation, collective action, and reflexive monitoring) were used to prepare for and support the dynamic nature of implementing a complex intervention into a complex organisational setting (Agreli et al., 2019; Murray et al., 2010). In the current intervention, a custom-designed project plan was developed following the Initiation, Surveillance, Sharing, Improvements and Plan for future (ISSIP) steps to describe and implement the processes (Table 1).

TABLE 1 Framework for SSI surveillance project using NPT constructs—Initiation, Surveillance, Sharing, Improvements and Plan for future (ISSIP) intervention.

Considerations	Key steps of implementation plan	NPT constructs (May, 2013)	Critical actions
Initiation	Objective	Coherence/Cognitive participation	• SMART aim using retrospective data to show the SSI rate of colorectal patients • Hospital management initiation based on international and national recommendations
	Readiness	Collective action/ Cognitive participation	• Chief Executive Officer of Hospital and Director of Nursing co-chairpersons of Infection Prevention and Control (IPC) Committee • Dedicated project lead facilitated by the Hospital Group • Engagement of surgeon, surveillance scientist and IPC team • Reporting feedback mechanism established monthly to IPC Committee which feeds into the hospitals' senior leadership team
	Expertise	Cognitive participation/ Collective action	• Dedicated human resource, with expertise in SSI, as project lead for the implementation of the intervention • Dedicated time from a surveillance scientist with expertise in SSI, surveillance and analysis • Evidence-based literature and the European policy reviewed and adapted to support intervention • Engagement from experts in education, surgery, i.e. director from the school of nurse education, antimicrobial pharmacist, colorectal surgeon
	Stakeholder involvement and planning	Collective action	• Included all known stakeholders in the development of the draft terms of reference for the implementation group which met bimonthly • Development of the SSI surveillance form to capture variables • Development of patient feedback form and electronic data collection tool • Education sessions planned
Surveillance	Commencing surveillance	Collective action/ Cognitive participation/ Coherence	• Surveillance processes planned and initiated • Education sessions were continuously delivered twice weekly over • 6 months • Face-to-face support for the clinical staff in all areas over the 6 months • Communication with and education of patients on SSI identification and the prevention and supply of discharge questionnaire to patients with a stamped envelope • A selection of educational posters and fliers displayed and rotated in surgical areas • Continuous data collection using MS access software by the project lead

	Nurturing	Coherence/Cognitive participation/ Collective action/ Reflexive monitoring	• Encouraging participation, ideas, evidence-based research and improvements
			• Listening to feedback from all clinical areas on the suggested changes required
			• Ideas that were nurtured
			  • Subgroup formed to review evidence-based interventions in the literature on care bundles where components were agreed that would suit the organisation, the team and the patient
			  • Development of a patient information booklet for patients undergoing major colorectal surgery
			  • Patient involvement in the review of booklet capturing patient perspective and views
			  • National Adult Literacy approval for the questionnaire and patient booklet
			  • Prescription developed for preoperative preparation with high-calorie drinks, medicated body wash, bowel preparation and antibiotics to prepare patients for surgery

Sharing	Sharing the data	Reflexive monitoring	• Feedback to clinical teams, hospital management, grand rounds, morning meetings, conferences • Patient self-reporting on SSI by post • Report on SSI rates for hospital infection prevention and control committee • Reporting outcome measures of SSI rates, the average length of stay, intensive care admissions, sepsis rates, reoperation rates • Shared the learning/lessons learned at local and national conferences to build on and contribute to the knowledge in the area of SSI prevention • Recognition of the contribution of surveillance to patient outcomes, HCWs knowledge and multidisciplinary collaboration

(Continues)

TABLE 1 (Continued)

Considerations	Key steps of implementation plan	NPT constructs (May, 2013)	Critical actions
Improvement	Continuous improvements	Reflexive monitoring/ Coherence/Cognitive participation	• Data led to quality improvement initiatives—monitoring the effectiveness of small tests of change with continuous changes to further embed intervention in practice • Refining of elements of the intervention—the surveillance form and the care bundle • Studies and projects contributed to the hospital's established quality improvement culture
Planning for future	Plan for further development and rollout	Coherence/Cognitive participation	• Plan for continuation of project and extension to their disciples • Requirements of dedicated SSI post, surveillance scientist and a platform for data • Strategy for long-term aim after the pilot • Subgroup started another project relating to rehabilitation

The intervention was an organisational-led intervention transcending many departments and involving the multidisciplinary team. In August 2018, the Infection Prevention and Control Team in the hospital prioritised the implementation of a systematic SSI surveillance intervention to reduce SSI rates. This complex intervention had several interacting components: leadership, formation of a SSI surveillance implementation group, education programme, new processes for capturing data relating to surgical site surveillance, a care bundle, a post-discharge questionnaire for patients, a patient information booklet for the colorectal patient cohort and processes for sharing data with feedback and support (Table 1).

A multidisciplinary implementation group was formed with engagement from multiple stakeholders from all perioperative areas, who provided care to patients undergoing colorectal surgery. This implementation group consisted of surgeons, anaesthesiologists, theatre nurses, surveillance scientist, nurse practice development, director for nurse education, antimicrobial pharmacist, ward staff, clinical nurse specialists (colorectal surgery, stoma therapy, infection control), theatre managers, theatre staff, recovery staff, outpatient clinic nursing staff, dietitian, occupational therapist, physiotherapist and the researcher who was also the facilitator for the project.

The educational component of the intervention was based on education packages delivered by Public Health England, the ECDC SSI protocol for surveillance of SSI and was informed by multidisciplinary input (European Centre for Disease Prevention and Control, 2017; Public Health England, 2013). Sessions were delivered by an expert in SSI who was also the main facilitator for the project. To access staff, education sessions were delivered for staff on surgical wards, theatres, outpatients' departments, doctors' meetings, and presentations were given at Grand Rounds, the hospital nursing conference, infection prevention and control meetings and at hospital management meetings. Maximising opportunities to access staff in a busy hospital setting is paramount in providing education to the multidisciplinary team (Basheer et al., 2018). These sessions were delivered twice a week in the clinical areas over 6 months. Education sessions were supplemented with the use of posters and flyers in all perioperative areas; these posters were changed weekly to reinforce the key information on surveillance.

The implementation group co-designed a new process for capturing data relating to surgical site surveillance which included an SSI surveillance form. A customised post-discharge questionnaire was developed through co-design and went through many iterations as feedback was received from patients and members of the multidisciplinary team. Quarterly reports were generated from surveillance data and the results were shared with all members of the multidisciplinary teams by presenting at sessions in all perioperative areas.

For the duration of the project, a facilitator worked daily to support staff in clinical areas. The facilitator continuously ensured an understanding of the intervention and promoted ownership of the processes by all healthcare professionals.

A care bundle was co-designed by the implementation group after reviewing key interventions in international best practice guidelines about prevention of SSIs in patients undergoing colorectal surgery.

A 48-page booklet titled *Your Guide to Bowel Surgery* was co-designed with input from patients and all members of the multidisciplinary team. The booklet guides patients on all aspects of their care from the decision to operate to returning home postoperatively. The booklet awarded the plain language stamp ensuring that booklet was comprehensible (National Adult Literacy Agency, 2021).

2.3 | Data collection

Baseline data on the knowledge and attitudes of healthcare staff was collected at pre-test. This was followed by the complex ISSIP intervention over 6 months and then a post-test questionnaire was administered (Time 2). At pre-test, 320 surveys were distributed with a 62.5% ($n = 200$) response rate and 300 surveys were distributed at post-test with a 49% ($n = 147$) response rate. This paper reported on the paired data obtained for 74 respondents completing the survey at both pre-test and post-test. The survey was distributed in person to all respondents at both periods. A cover letter

explained that the survey was to be paired where pre- and post-surveys were completed. The surveys were returned by respondents into designated boxes in convenient locations in the hospital and were collected daily by a member of the research team.

Process indicators were collected on elements of SSI surveillance provided during education and support provided by the facilitator throughout the study. These indicators included compliance with monitoring of temperature, blood glucose levels, correct timing of surgical antibiotic prophylaxis, hair removal practices, use of surveillance form and details of wound contamination classification (Horgan et al., 2023). Outcome measures included level of knowledge and attitudes of healthcare professionals towards SSI, SSI prevention and surveillance at two time points six-months apart.

2.4 | Sample

A convenience sample of registered healthcare professionals (surgeons, theatre nurses, recovery room nurses, ward nurses, intensive care nurses, anaesthetists, junior doctors, clinical nurse specialists and infection control nurses) involved in the care of patients undergoing surgery were invited to participate in this research.

2.5 | Inclusion and exclusion criteria

Registered healthcare professionals including doctors, nurses and allied healthcare professionals from across the surgical directorate who were involved in the care of a patient undergoing colorectal surgery were eligible for participation in the study. Students from healthcare programmes and healthcare professionals working outside of perioperative areas were excluded.

2.6 | Measures

The pre-test questionnaire consisted of 20 questions over four sections (Table 2). Section one included demographic questions. In section two, knowledge of SSI and a SSI prevention was measured using 10 multiple-choice questions; nine of the multiple-choice knowledge questions were adopted from Labeau et al. (2010) study which examined the knowledge on recommended postoperative wound management, classification of SSI, knowledge on correct hair removal practices and postoperative bathing practices among nurses. A single question on wound contamination classification was researcher-developed and measured using a multiple-choice question which examined respondents' knowledge of the wound contamination classification which classifies surgeries into four categories: clean, clean/contaminated, contaminated or dirty (European Centre for Disease Prevention and Control, 2017). Question 15 was developed by the researchers and measured the knowledge of SSI risk factors scale. The scale consisted of 10 risk factors that may predispose a patient to infection, three of which were incorrect: raised haemoglobin, history of tonsillectomy and epilepsy.

Attitude to SSI prevention and surveillance was measured using researcher-developed statements, in section three, with responses on a five-point Likert scale ranging from 'strongly agree' to 'strongly disagree'.

The questionnaire was given to eight experts to rate using a Content Validity Index (CVI) (Polit et al., 2007). The experts individually rated each survey item to ascertain whether it was clearly written and relevant. The panel included three hospital consultant doctors and five nurses of varying grades from director of nursing to clinical nurse manager including one from infection control. The 20 items presented to the expert panel met the predetermined standard of 0.78 or higher for each item in the Individual CVI (I-CVI) and 0.90 for scales for three or more experts (Polit et al., 2007). In this

TABLE 2 Data collection instruments.

Instrument	Source	No of items	Answer options	Scoring	Interpretation of scores	Reliability
Sociodemographic Questionnaire	Researcher designed	4	Closed-ended questions	NA	NA	NA
Knowledge of SSI and SSI prevention Questionnaire	Labeau et al. (2010)	10	Multiple choice with one correct answer	Correct answer = 1 1–10	Higher scores indicate greater knowledge	Cronbach's alpha 0.77 in the pre-test and 0.76 in the post-test
Knowledge of SSI risk factors scale	Researcher designed	1	Dichotomous yes/no answers to indicate if an SSI risk factor	Correct answer = 1 0–10	Higher scores indicate greater knowledge of SSI risk factors	Dichotomous items which did not form a scale therefore Cronbach's alpha was not appropriate
Attitudes towards SSI, SSI prevention and SSI surveillance	Researcher designed	5	Level of agreement assessed on a 5-point Likert scale	5–25	Higher scores indicate more positive attitude	Cronbach's alpha 0.77 pre-test and 0.72 post-test

study, the CVI-I result was 0.85 for universal agreement and the average in the I-CVI was 0.95, indicating excellent validity.

Cronbach's (1951) alpha was 0.77 in the pre-test for a 10-item knowledge of SSI and prevention scale and 0.76 in the post-test, indicating good levels of internal consistency of the scale (Taber, 2018) (Table 2). Results of the Cronbach's alpha of the attitudes to SSI prevention and surveillance scale indicated good internal consistency (Tavakol & Dennick, 2011).

2.7 | Analysis

Data were entered into the Statistical Package for the Social Sciences (SPSS) by one of the researchers and reviewed by a statistician (IBM, 2017). Descriptive statistical analysis was conducted to describe the sample and the knowledge level on risk factors, comorbidities for SSI and the attitude level of the sample. The mean pre-test and post-test scores for each question on the knowledge of SSI and prevention, risk factors that can predispose patients to SSI and attitude to SSI prevention and surveillance levels were compared using paired sample *t*-tests. McNemar's test and paired samples *t*-test were used to compare differences in total knowledge and attitudes at the two time-points.

2.8 | Ethical considerations

Ethical approval was obtained from the Clinical Research Ethics Committee of Cork Teaching Hospitals—ECM (l) 16/10/18. Completion and return of the survey indicated a willingness to participate in this study and was taken to infer consent to participate. Completed surveys were stored in a secure location in compliance with General Data Protection Regulations. When a participant agreed to take part in the survey, a code was assigned allowing follow-up from pre-test to post-test. This generated a dataset in which each data point in one sample was uniquely paired to a data point in the second sample.

3 | RESULTS

Data pertaining to the 74 respondents who completed the survey in both Pre-test and Post-test are outlined in this paper. The profile of respondents is outlined in Table 3. The majority of respondents were female 68.9% ($n=51$), and nurses (72.6%, $n=53$). Over two-thirds of the sample (68.4%, $n=50$) had over 5 years' experience in their current profession with 31.1% ($n=23$) reporting that they had had prior education in SSI.

3.1 | Knowledge of SSI and SSI prevention

Knowledge of SSI and SSI prevention showed moderate changes with higher scores indicating greater knowledge (Table 4). There was a statistically significant increase in average knowledge scores from pre-test with a mean score of 3.47 (SD = 2.02) to post-test where there was a mean of 4.46 (standard deviation [SD] = 2.19), $p<0.001$. The mean increase in knowledge scores was 0.99 (95% CI: 0.45 to 1.52). Pre-test, no respondent answered more than eight out of ten questions correctly; only 22.9% ($n=23$) of respondents had a score of ≥5 and 69% ($n=51$) of respondents answered <5 items correctly (95% CI: 3.0, 3.9). Post-test, 47.3% ($n=35$) of respondents had a score of ≥5 with 52.8% ($n=39$) of respondents having answered <5 items correctly. Notably 69% ($n=51$) of respondents reported having not received previous education on SSI.

TABLE 3 Demographic profile of study participants.

Variable	Paired pre- and post-test responses ($n=74$) % (n)
Gender	
Male	31.1 (23)
Female	68.9 (51)
Experience in your role (months)	
0–12	5.5 (4)
13–61	26.0 (19)
62–109	20.5 (15)
110–158	17.8 (13)
>159	30.1 (22)
Unknown	1.4 (1)
Occupation	
Doctor	21.6 (16)
Nurse	72.6 (53)
Other	5.5 (4)
Unknown	1.4 (1)
Prior education in SSI	
Yes	31.1 (23)
No	68.9 (51)

3.2 | Knowledge of risk factors that can predispose patients undergoing surgery to SSI

Knowledge of risk factors that predispose patients to SSI was measured using a 10-item list with dichotomous yes/no answers. The higher the score in the range of 0–10, the greater the knowledge of risk factors. Using McNemar's statistical test for paired nominal data there was a notable improvement in knowledge of four of the risk factors ($p<0.05$). There was a 15.1% increase in knowledge in two of the comorbidities of raised blood glucose in the non-diabetic patient and the presence of diabetes mellitus. In addition, there was a 20.6% increase in the knowledge of the risk factor of chronic obstructive pulmonary disease and a 16.4% increase in the awareness of chronic kidney disease as a predisposing factor in the development of an SSI. Based on all respondents

TABLE 4 Knowledge of SSI and prevention.

Items	Correct answer	Pre-and post-test ($n=74$)		
		Pre-test: Correct, % (n)	Post-test: Correct, % (n)	p-Value[a]
1. It is recommended to protect a primarily closed incision?	During the first 24–48 h following the surgery	39.2 (29)	39.2 (29)	1
2. The appropriate time to shower and bathe?	Unresolved by lack of evidence	8.1 (6)	23.0 (17)	0.013
3. Surveillance succeeds in reducing the incidence of SSI?	Yes and without supplementary preventive measures	16.2 (12)	24.3 (18)	0.327
4. Elective surgeries on patients with remote site infections should be postponed until the infection has resolved?	This is true of all patients	50.0 (37)	55.4 (41)	0.556
5. SSI are classified as Superficial incisional SSI, deep incisional SSI, and organ/space SSI	True	28.4 (21)	43.2 (32)	0.043
6. Stitch abscesses are classified as SSIs?	False	12.2 (9)	28.4 (21)	0.012
7. To be classified as SSI, a superficial incisional infection needs to occur?	Within 30 days	33.8 (25)	36.5 (27)	0.824
8. If the patient's hair at or around the incision site interferes with the operation, it is recommended to remove it by?	Electric clippers	63.5 (47)	68.9 (51)	0.556
9. The recommended time of pre-operative hair removal in elective surgery is?	Immediately before the surgery	36.5 (27)	60.8 (45)	0.005
10. Which of the following is the internationally recognised Wound Classification System used to assess the degree of contamination of a surgical wound?	Clean, clean- contaminated, contaminated, Dirty or infected	59.5 (44)	66.2 (49)	0.458
Total scale score: mean (SD)		3.47 (2.02)	4.46 (2.19)	<0.001[b]

[a]McNemar's test unless otherwise stated.

[b]Paired t-test.

TABLE 5 Knowledge of risk factors that can predispose patients undergoing surgery to SSI.

Risk factors that can predispose patients undergoing surgery to SSI	Pre- and post-test ($n=73$)		
	Pre-test: Correct, % (n)	Post-test: Correct, % (n)	p-Value[a]
Chronic obstructive pulmonary disease	35.6 (26)	56.2 (41)	0.003
Raised white cell count	78.1 (57)	82.2 (60)	0.424
Raised haemoglobin[b]	97.3 (71)	87.7 (64)	0.065
Chronic kidney disease	42.5 (31)	58.9 (43)	0.038
History of tonsillectomy[b]	90.4 (66)	94.5 (69)	0.453
Current cancer	60.3 (44)	58.9 (43)	1
Currently on corticosteroids	67.1 (49)	75.3 (55)	0.238
Epilepsy[b]	95.9 (70)	91.8 (67)	0.508
Diabetes mellitus	78.1 (57)	93.2 (68)	0.007
Raised blood glucose	43.8 (32)	58.9 (43)	0.035
Total scale score: mean (SD)	6.89 (1.77)	7.58 (1.77)	0.004[c]

[a]McNemar's test unless otherwise stated.

[b]Not the risk factors.

[c]Paired t-test.

TABLE 6 Attitude to SSI and surveillance.

Attitude question	Pre and post-test ($n=72$)[a]		
	Pre-intervention mean (SD)	Post-intervention mean (SD)	p-Value[b]
Q1 The identification of SSIs is a priority for the health care team where I work	4.11 (0.958)	4.38 (0.846)	0.023
Q2 Follow-up monitoring is available for patients post-surgery where I work	3.34 (1.273)	3.75 (1.045)	0.034
Q3 Overall, I am confident that I can recognise the risk factors that predispose patients to SSI	3.96 (0.863)	3.97 (0.949)	0.915
Q4 I have the knowledge to advise others (e.g. patients, students) on how to prevent SSI	3.83 (0.904)	3.90 (0.906)	0.519
Q5 It is my responsibility to assist in the prevention of SSI where I work	4.61 (0.640)	4.68 (0.526)	0.373
Total scale score	19.875 (3.142)	20.680 (2.857)	0.046

[a]Two participants did not answer the attitudes section.

[b]From paired t-test.

who participated pre- and post-intervention, the knowledge of risk factors score post-test mean was 7.58 (SD = 1.77) which was significantly higher than pre-test mean of 6.89 (SD = 1.77; $p < 0.004$) (Table 5).

3.3 | Attitude towards SSI and SSI prevention

Attitudes were measured with five Likert scale questions with a range of 1–5 for each question and a range of 5–25 for total scores. Two respondents who answered the knowledge questions did not answer the attitude questions, which was the last section of the questionnaire ($n=72$).

Two of the questions were organisational-level attitude questions while three focused on personal attitudes. In the sample of respondents who completed the attitudes section in both pre and post-test, those in the pre-intervention achieved a mean score of 19.87 (SD = 3.14) and post-test of 20.68 (SD = 2.86). The results demonstrated a positive attitude overall to SSI prevention and surveillance both pre- and post-test. A comparison of the mean total attitude to SSI prevention and surveillance scale results between pre-test and post-test showed a difference in the means of 0.80 (CI: −1.598 to −0.128) (Table 6). A paired sample t-test was conducted to compare the pre and post-test scores (t [72] = −2.026, $p = 0.046$) which was statistically significant, indicating that total mean scores improved following the intervention; however, the change was relatively small and, although it was statistically significant, may not have been clinically significant. Pre-test, 82.1% ($n=59$) of the respondents believed that the identification of SSI was a priority in their place of work with 91.6% ($n=66$) were in agreement that it is their responsibility to assist in the prevention of SSI. Pre-test, 69.4% ($n=50$) of respondents identified that they had the knowledge to educate others on SSI and 79.2% ($n=57$) reported they could recognise the risk factors that predispose patients to SSI. The results showed minimal change in the scores post-test.

In the two other organisational-level questions, where the respondents were asked if SSI was a priority where they worked and that follow-up monitoring was available in the hospital, there was a statistically significant change in scores between pre-test and post-test.

4 | DISCUSSION

This study explored the effect of the implementation of SSI surveillance as a complex intervention on the knowledge and attitudes of HCPs towards SSI, SSI prevention and SSI surveillance in a hospital setting. The findings reveal that there was an overall positive impact of the ISSIP complex intervention on the knowledge and attitudes of healthcare professionals about SSI, SSI prevention and SSI surveillance; however, the extent of the change varied across measures. While there was a statistically significant increase in average knowledge of SSI and SSI prevention scores and the knowledge of SSI risk factors scores from pre-intervention to post-intervention, there was minimal change in some areas. Knowledge of the wound contamination classification, correct method of hair removal, protection of wounds and the need to postpone elective surgery if the patient has an infection at the time of elective surgery were all areas that require further attention. Wound contamination classification is a key variable required for SSI surveillance, one-third of the respondents in post-test did not know the correct answer which warrants further attention in the clinical setting. This wound contamination classification is necessary for risk stratification for SSI in surveillance and improving knowledge on its importance and the consistent use of the classification system has been a challenge (European Centre for Disease Prevention and Control, 2017; Qasem & Hweidi, 2017).

The pre-test knowledge of SSI and SSI prevention score was low with a mean of 3.55 which was marginally higher than findings in previous studies (Labeau et al., 2010). However, the present study included the full multidisciplinary team, whereas previous studies measured nurses' knowledge only. The previous studies examined the knowledge of intensive care nurses (Labeau et al., 2010) and ward nurses (Qasem & Hweidi, 2017), respectively, whereas in the current study, participants worked in a wide variety of perioperative areas.

Despite extensive efforts to improve knowledge throughout the study and a statistically significant improvement in knowledge, the overall mean knowledge score remained relatively low at 4.46 (SD = 2.19). Staff in clinical settings are constantly changing and the practice of surveillance for SSI prevention is new for the hospital, thus it is critical that education and reinforcement continues beyond a single study. This is particularly important as the pre-test results demonstrated low knowledge levels and some changes post-test were moderate. A single education session may not have been enough to improve knowledge, given that the hospital was in its infancy in engaging with surveillance, did not have a guideline in place on SSI prevention and that 69% of respondents had not previously received any SSI prevention training. Sustaining and improving knowledge levels of healthcare professionals require continuous education delivered on a regular basis (Saffari et al., 2019). Geberemariyam et al.'s (2018) study of 30 healthcare facilities found that knowledge levels of healthcare professionals with regards to infection prevention were better where there were local infection prevention and control guidelines in place.

A Cochrane review concluded that education on healthcare guidelines alone is not as effective as a locally designed multifaceted intervention (Baker et al., 2015). This study re-examined the knowledge of SSI and prevention scores after the ISSIP complex intervention which showed a significant improvement which is similar to other studies that reported using a multiple methods intervention to improve the knowledge of evidence-based practices in relation to infection control measures (Allegranzi et al., 2016; Blanco-Mavillard et al., 2021; Daisy & Sreedevi, 2015; Zingg et al., 2014).

Similarly, knowledge of risk factors that can predispose patients to SSI significantly improved following the ISSIP complex intervention. To date, no other study was sourced which looked at knowledge of risk factors. Many studies have concluded that risk factors such as being immunocompromised, hyperglycaemic or having a raised white blood cell count increase SSI incidences (Canedo et al., 2013; Jackson et al., 2012; Nguyen et al., 2014). Healthcare professionals need to be aware of which patients are more at risk and utilise this information to assist them to mitigate the risk through quality improvement measures using evidence-based interventions (European Centre for Disease Prevention and Control, 2017). Whilst the post-test mean score for knowledge of risk factors was relatively high, one in five participants in the attitude section did not feel confident in their knowledge in recognising risk factors that predispose patients to SSI and lacked confidence in educating others. It has been identified that structured education programmes can improve confidence through continuous learning and support (Abu Sharour et al., 2018; Tawalbeh, 2020).

It was identified that there was a positive overall attitude to SSI prevention and surveillance at Times 1 and 2. Overall, findings relating to the attitude towards SSI and SSI prevention scale showed a small but statistically significant change post-intervention; however, some areas did not change significantly and need further attention. There was a statistically significant difference from pre-test to post-test in organisational level attitudes where the respondents were asked if SSI was a priority where they worked and that follow-up monitoring was available in the hospital. Areas that did not show significant changes were the healthcare professionals confidence in educating patients and staff in relation to SSI, in recognising risk factors that place patients at higher risk of developing an SSI and in their role in relation to SSI prevention. To the best of our knowledge, this is the first study to look at both knowledge and attitudes of healthcare professionals on SSI in a study using a pre-test and post-test design. Troughton et al. (2019) also reported that the majority of surgical multidisciplinary staff have positive attitudes towards SSI surveillance and believe that are responsible for the prevention of SSI. Recently, other researchers have concluded that continuous engagement in SSI surveillance as part of a complex intervention at

an organisational level improves awareness by clinicians of patient safety and results in better outcomes (Morikane et al., 2021; Zucco et al., 2019).

The ISSIP intervention was guided by NPT constructs. Cognitive participation was critical in ISSIP intervention where leadership, surgeons and surveillance scientists were major drivers and champions of this initiative. Involvement of champions from clinical areas, hospital management, surgeons and surveillance scientist has been beneficial in other past studies (Anderson et al., 2014; Hegarty et al., 2019; Morikane et al., 2021; Sartelli et al., 2018).

Coherence, as part of the NPT process, created understanding in how the components of the intervention interacted with each other. The role of a dedicated facilitator provided unity and sustainability in this multifaceted intervention whilst also helping to prevent infections thus reducing costs and driving efficiencies. This role provided education, support and enforced learning for both, patients and personnel. This study, similar to previous studies, used the role of facilitator to work with all disciplines; these roles have been found to be effective in increasing awareness of SSI and SSI surveillance (Lin et al., 2020; Troughton et al., 2019). It was through collective action in everyday practice that the operational approaches resonated and resulted in contribution, collaboration and involvement in co-design, which was also found in other studies (Lin et al., 2020; Morikane et al., 2021). Reflexive monitoring is imperative in SSI surveillance as it is the monitoring, analysis and feedback of data that embodies surveillance and its success at reducing SSIs. The surveillance process encourages continuous improvement, patient safety culture and sustainability of this initiative.

With multiple interacting components in this intervention, it is impossible to identify any one component of the intervention as producing the change which is similar to findings from other studies (Blanco-Mavillard et al., 2021; Zingg et al., 2014). In this study there were comparable findings to Blanco-Mavillard et al. (2021) where a multimodal intervention brought about many changes particularly to the knowledge of healthcare professionals but also in feedback on infection rates and engagement in evidence based practice. A strength of the current study was the inclusion of stakeholders, such as doctors, nurses, anaesthetist, dietitians, surveillance scientist, pharmacists and patients from an early stage of the design of the intervention; this increased applicability and facilitated implementation. The implementation group coordinated the project and maintained focus and drive throughout the project. Each time a difficulty was identified, potential solutions were explored by the implementation group or by frontline staff.

4.1 | Limitations

There were limitations in this study. Firstly, the changeover of nursing and medical staff resulted in only 74 participants in the paired sample. The authors acknowledge that the absence of a control group is a limitation however, recruitment can be challenging in a busy clinical setting. Future studies could enhance learnings from the present study by using a randomised controlled design to further investigate the effectiveness of a complex intervention similar to ISSIP. There is currently no national guideline on SSI prevention to support knowledge acquisition in the clinical setting for healthcare professionals in Ireland which could have contributed to the low baseline levels of knowledge measured, while there was an improvement noted from pre-test to post-test in the question on the knowledge of risk factors the reliability analysis was questionable.

5 | CONCLUSIONS

This study resulted in positive findings of the effects of a complex intervention on the knowledge and attitudes of healthcare professionals relating to SSI and surveillance. Utilising NPT constructs to tailor the ISSIP intervention was effective as a framework to understand how projects with multiple components interact with each other. Pre-test and post-test design was beneficial to evaluate the impact of a complex intervention and in identifying further opportunities for improvement in education and support. The assistance of a locally targeted implementation model such as ISSIP could serve as an acceptable systematic approach for similar SSI prevention initiatives. This study implemented and evaluated a multifaceted complex intervention and concludes that having the correct structures in places such as leadership, an evidence-based guideline, an implementation group, a dedicated facilitator, ongoing education, a surgeon champion and the expertise of a surveillance scientist were pivotal to the success of the project.

This study recommends that surveillance is a continuous process to embed the knowledge and SSI prevention processes. A further recommendation is for the development of a national clinical guideline on SSI surveillance with an implementation plan to provide explicit guidance to hospitals and promote a standardised national approach to implement SSI surveillance. Finally, future longitudinal and controlled studies should be undertaken to further measure how complex interventions impact on SSI incidence rates.

5.1 | Relevance to clinical practice

Implementing interventions and improving the knowledge and attitudes in relation to the prevention of SSIs in the clinical setting can be challenging and studies that examine strategies that assist in the successful implementation of interventions and improvement of knowledge and attitudes are of benefit to healthcare organisations. This study shows that an interdisciplinary multicomponent complex intervention can effectively improve knowledge and attitudes of healthcare professionals in relation to SSI, prevention and surveillance. The NPT provides support for complex interventions in deterring SSIs by presenting factors to consider when implementing interventions. In addition, NPT considers how people collaborate within the organisation and the dynamics of structures with in a clinical setting and assists in addressing the barriers often experienced in the healthcare settings when implementing change.

AUTHOR CONTRIBUTIONS

Sinéad Horgan conceived the presented idea. Sinéad Horgan developed the study and performed the computations. Josephine Hegarty and Jonathan Drennan verified the analytical methods and supervised the findings of this work. Emmet Andrews and Sinéad Horgan lead the complex intervention in the clinical setting. All authors provided critical feedback and helped shape the research, analysis and manuscript.

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The data that support the findings of this study are available from the corresponding author upon reasonable request.

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