Infection control link nurses in acute care hospitals

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INFECTION CONTROL LINK NURSES IN ACUTE CARE HOSPITALS

Strategies to improve implementation and effectiveness

Mireille Dekker

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The studies presented in this thesis were conducted at the Department of Medical Microbiology and Infection Prevention of Amsterdam UMC, Vrije Universiteit Amsterdam, in collaboration with Amsterdam Public Health research institute, the Netherlands.

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Strategies to improve implementation and effectiveness

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door

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CONTENTS

CHAPTER 1

General Introduction

Healthcare associated infections and antimicrobial resistance

Healthcare associated infections (HAI) are infections acquired during treatment in a health care facility[1]. These infections are associated with adverse outcomes, such as morbidity and mortality, a prolonged duration of hospital stay, and an increase in costs. They are therefore burdensome for both individual patients as well as for the health care system[2-5]. In Europe, on average, 6.5% (95%CI 5.4-7.8) of patients in acute care hospitals are affected by HAI; this means that 3.8 million (95%CI 3.1 - 4.5) patients in European hospitals acquire an infection each year[6]. In the Netherlands, the burden of HAI is comparable, with a prevalence estimated at 7.2% (95%CI 6.4 - 8.1), based on national surveillance data from 2020[7].

The discovery of antibiotics has made a major contribution to the treatment of bacterial infections[8]. The widespread use and overuse of these antibiotics has accelerated the evolution of antimicrobial resistance (AMR) of microorganisms and has made many antibiotics less effective[9]. According to recent estimates, 5.0 million (95%CI 3.6 - 6.6 million) deaths were associated with AMR worldwide in 2019, including 1.3 million (95%CI 0.9 - 1.7 million) deaths attributable to bacterial AMR. In other words, if all these infections were caused by drug-susceptible microorganisms, 1.3 million deaths could have been prevented[10].

In acute care hospitals, AMR microorganisms pose a serious risk to patients[11]. These microorganisms are introduced into the hospital by colonized or infected patients, and the relatively high use of antibiotics in hospitals promotes the selection of these drug-resistant strains[11, 12]. Transmission to other patients occurs directly or indirectly, by healthcare workers or the hospital environment[11]. An increasing proportion of HAI is caused by these AMR microorganisms[13]. In 2020, in the Netherlands, AMR concerned 11.9% (95%CI 8.5-16.4) of HAI[7].

Infection prevention and control

The careful application of basic infection prevention and control (IPC) guidelines by health care professionals is crucial in lowering the burden of healthcare-associated infections and in reducing the emergence of antimicrobial resistance. IPC measures help to limit the spread of microorganisms and subsequently prevent HAI[14-16]. The World Health Organization (WHO) calculated that IPC measures can prevent up to one third of HAI, leading to fewer patients in need for antibiotic treatment and thus a reduction of the use of antibiotics; this is important to slow down the development of antibiotic-resistant organisms[14, 17]. The Organization for Economic Co-operation and Development (OECD) reported the potential reduction of 40% of the AMR health burden by the promotion of basic IPC measures[18].

Strategies to implement infection prevention and control

The European Centre for Disease Prevention and Control (ECDC) and the WHO provide evidence-based guidance on how to organize and manage infection prevention in hospitals, and recommend:

1. to translate guidelines and policies into local protocols taking into account the local context,
2. to contribute to risk assessment and quality improvement by
   - education and training of staff
   - surveillance of HAI and management of outbreaks
   - audit and feedback of IPC practices,
3. to manage capacity of the hospital with standards for bed occupancy, levels of staff and workload,
4. to ensure a hygienic hospital environment, and,
5. to implement IPC guidelines using multimodal strategies[19, 20].

Implementation of IPC guidelines is challenging and adherence to IPC measures in known to be poor[21, 22]. Practicing hand hygiene for instance is a simple and effective way to prevent infections. Despite the awareness of health care workers of the need to perform hand hygiene, and despite many interventions to improve adherence, compliance with hand hygiene is still around 50%[23]. Often health care workers fall back into their routines once the external stimulus to improve discontinues[24].

To improve guideline adherence, behavioral change is a prerequisite; such change requires complex strategies[25-27]. These strategies usually combine several activities, that are implemented in an integrated way[28-30]. The 2017 Geneva Think Tank, a panel of international experts, concluded that the challenge now is to learn from studies that describe the use and impact of these strategies in various contexts[31]. It stresses the importance to invest in multimodal interventions to improve the compliance with IPC guidelines.

Infection control link nurses

Implementation of IPC guidelines in acute care hospitals is usually the task of the infection prevention and control team. One of the interventions that IPC teams can set up to implement IPC guidelines, is to establish collaborations with nurses. At the operational level nurses can have a profound impact on the prevention of infection; they are involved in the provision of care in every area of the hospital[32]. One strategy to accommodate this collaboration and to involve nurses in infection prevention is by the appointment of link nurses. Traditionally, link nurses liaised between the epidemiology department and clinical wards for the surveillance of HAI. Nowadays link nurses help to raise awareness for infection control by

educating colleagues and motivating them to improve practice[20, 33-35]. To fulfil this role, link nurses are trained by infection control practitioners. Activities to support link nurses, including this training, are referred to as link nurse programs and can be considered as a complex strategy. Since their first introduction in the 1980's in the United States of America and the United Kingdom, ICLN have been appointed in hospitals worldwide, indicating that this complex intervention is considered an effective approach[36, 37]. In recent years, the Royal College of Nursing formulated a generic role profile for ICLN in the United Kingdom[38]. The European Centre for Disease Prevention and Control recommends the collaboration with link nurses[20]. In German acute care hospitals, ILCN are mandatory and in many Dutch hospitals, infection prevention and control teams are supported by ICLN[39, 40].

Despite the popularity of ICLN programs, there is a scarcity of studies on the effects of link nurses on the uptake of IPC policies and on the programs that train and support these link nurses in acute care hospitals. Therefore, there is a lack of understanding of the variation of existing link nurse programs and the contextual factors that have led to this variation. Studies unraveling these complex interventions can reveal opportunities to improve the value of ICLN programs and to reduce their inefficiencies in the implementation of infection prevention practices and the subsequent reduction of hospital acquired infections.

Infection control link nurse programs through the lens of implementation science

Implementation science seeks to improve the quality of healthcare by studying methods that promote the systematic uptake of evidence-based practices in day to day care[41]. Its principles can inform our efforts to ensure the effective implementation of infection prevention. In other words, this field can help to provide information about how to improve the outcomes of ICLN programs[42]. Implementation science uses a variety of theories, models, and frameworks and provides a broad scope on improvement by focusing on various levels of healthcare, including the patient, health care workers, setting and policy level[42, 43]. Implementation theories can help to understand the important elements of implementation, it applies knowledge from the fields of psychology, sociology, and organizational theory. A model is a graphical representation of an idea or a concept and a framework provides an overview of components, dimensions, and directions. Models can help to describe or guide the translation of research findings into practice. Frameworks can help to understand and explain what influences the outcomes of implementation[42].

To investigate which factors influence the effective uptake of infection prevention practices with the help of ICLN programs, the Consolidated Framework for

Implementation Research (CFIR) can be used. The CFIR is a meta-theoretical framework. It is designed to improve the understanding of the critical determinants that may influence the implementation of complex interventions, such as ICLN programs[44]. The CFIR is based on existing theories and synthesizes their concepts in 5 interrelated domains (figure I). Each of these domains includes theoretical concepts that are referred to as constructs.

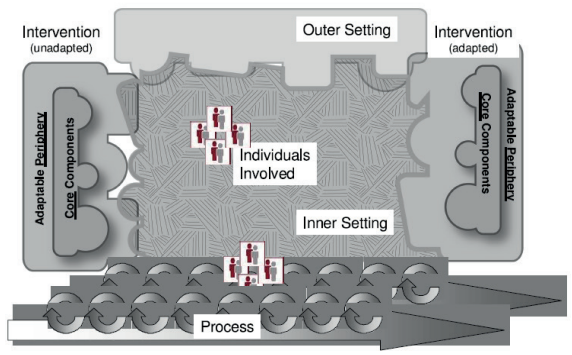

Figure I. The Consolidated Framework for Implementation Research [44, 45]

The first domain, the intervention, describes the key attributes of an ICLN program. It also contains the features which may influence the implementation of a link nurse program: the perception of microbiologists, infection control practitioners, hospital and ward managers, link nurses and other stakeholders on the quality and the source of the program, and the value of a link nurse program over other options.

The outer setting, the second domain of the framework, describes the context of the hospital at a meta-level. It includes the degree to which a hospital is linked to other hospitals in its region, the competition with or peer pressure from these hospitals and other external incentives to implement infection prevention and control guidelines.

The inner setting describes the structure of the hospital, the dynamics of informal networks and lines of communication. This third domain characterizes the implementation climate (e.g. is infection prevention a priority in the hospital) and readiness for implementation (e.g. what indicators underpin the decision to implement a link nurse program) of the hospital.

The fourth domain describes the way the individuals are involved in the development and the implementation of a link nurse program to capture and understand the dynamics between these individuals and the hospital and its influence on the implementation process.

The fifth domain delineates the planning, execution, reflection and evaluation of the intervention: the process of implementation. Since an ICLN program is characterized by constant change, this domain reflects the non-linearity of implementing and maintaining a link nurse program. The different roles of individuals that engage in this process are explored and classified as opinion leaders, formally appointed internal implementation leaders, champions or external change agents.

The CFIR has proven to be applicable to guide the assessment of factors that affect the successful implementation of complex interventions in various settings[46]. It addresses the complexity of the implementation of interventions and acknowledges its nonlinear process. The CFIR incorporates the adaptations that are often needed to successfully implement interventions in various contexts and at different levels, and provides a common vocabulary to discuss barriers, facilitators, and strategies to implementation. In this thesis facilitators and barriers are connected to the CFIR domains and their constructs to identify opportunities to maximize the impact of infection control link nurse programs on the uptake of IPC guidelines.

Outline of this thesis

This thesis describes the link nurse role and link nurse programs in the context of acute care hospitals. It aims to explain how current programs could be improved to support ICLN, to evaluate the effectiveness of ICLN programs in improving compliance with infection prevention and control guidelines and, finally, to provide strategies for further implementation of these programs. The main research questions are:

I. What are the characteristics and success factors of link nurses and link nurse programs in acute care hospitals?
II. What are the effects of infection control link nurse programs on IPC processes and outcomes?
III. How can link nurse programs be effectively implemented?

The first part of this thesis focusses on the concept of the infection control link nurse. **Chapter 2** is a review of the literature on key concepts of link nurses and link nurse programs, the effects of such programs, and gaps in the evidence base. **Chapter 3** investigates the variation in infection control link nurse programs in Dutch acute care hospitals and identifies elements that are associated with successful dissemination and implementation of infection prevention and control policies. **Chapter 4** explores the experiences of link nurses regarding their role, to understand what support they need to fulfil their role in an optimal way.

The second part of this thesis evaluates the impact of an ICLN program. **Chapter 5** measures compliance with the hospital dress code, assesses causes of noncompliance with the input of the infection control link nurses, and finally assesses whether a behavioral approach is effective in improving compliance. **Chapter 6** evaluates the effects of a link nurse program in a Dutch academic hospital using a the RE-AIM framework to systematically describe several aspects important for implementation.

The third part provides a synthesis of the results and a general discussion on infection control link nurses and the programs that support these nurses. **Chapter 7** sums up the barriers to the implementation of ICLN programs that were found in part one and two of this thesis and uses the CFIR to identify strategies to improve implementation of current ICLN programs or to drive their future implementation. **Chapter 8** systematically summarizes and discusses the main findings of this thesis and provides recommendations for further research and practice.

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CHAPTER 2

The role of infection control link nurses, infection control link nurse programs and their effects; a scoping review

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Infection control link nurses in acute care hospitals: a scoping review
Antimicrobial Resistance & Infection Control. 2019;8:20.

ABSTRACT

Background

Involving link nurses in infection prevention and control is a strategy to improve clinical practice that has been implemented in hospitals worldwide. However, little is known about the use, the range and benefits of this strategy. We aimed to identify key concepts of infection control link nurses (ICLN) and ICLN programs, to evaluate the effect of such programs, and to identify gaps in the evidence base.

Methods

In a scoping review, we searched PubMed, CINAHL, Google and Google Scholar for manuscripts on ICLN in acute care hospitals. We included research- and opinion-based papers, abstracts, reports and guidelines.

Results

We included 29 publications and identified three key concepts: the profile of ICLN, strategies to support ICLN, and the implementation of ICLN programs. The majority of included studies delineates the ICLN profile with accompanying roles, tasks and strategies to support ICLN, without a thorough evaluation of the implementation process or effects. Few studies report on the effect of ICLN programs in terms of patient outcomes or guideline adherence, with positive short term effects.

Conclusion

This scoping review reveals a lack of robust evidence on the effectiveness of ICLN programs. Current best practice for an ICLN program includes a clear description of the ICLN profile, education on infection prevention topics as well as training in implementation skills, and support from the management at the ward and hospital level. Future research is needed to evaluate the effects of ICLN on clinical practice and to further develop ICLN programs for maximal impact.

BACKGROUND

Health care associated infections cause significant morbidity and mortality in patients and form a financial burden to health care systems[1]. Appropriate application of universal precautions (e.g. hand hygiene) by health care workers has been proven effective in reducing transmission of microorganisms and subsequent acquisition of health care associated infections[2]. Still, in general, compliance with these simple infection control measures is low[3, 4].

A strategy to improve compliance is to involve dedicated nurses in infection prevention and control. Such dedicated nurses or infection control link nurses (ICLN) act as a link between their own clinical area and the infection control team and raise awareness of infection prevention and control. They are trained to educate colleagues and motivate staff to improve practice[5, 6]. Since their first introduction in the 1980's, ICLN have been appointed in hospitals worldwide; they usually work within a hospital-based network[7-13]. The major investment in time and effort of the infection control team and link nurses that accompanies the implementation of an ICLN program is generally perceived as worthwhile [5, 14, 15].

An initial search for literature on ICLN and the interventions (e.g. programs) that are used to set up and maintain ICLN networks, however, revealed a lack of research on the effectiveness of ICLN in improving compliance with infection control guidelines or their impact on patient outcomes (e.g. health care associated infections)[16]. Before advocating ICLN programs, a better understanding of the use, range and benefits of these programs is needed.

A recent systematic review, focusing on facilitators and barriers of ICLN networks, included ten studies with a large variation in design and outcomes[17]. The authors searched only medical orientated databases, although the subject of study were nurses. Not searching nursing-orientated databases nor the grey literature in a relative unexplored field resulted in a small set of studies. To be able to assess all the available literature on link nurse programs in infection control in acute care hospitals we searched for studies published in different databases and in the grey literature. We looked at the key features of ICLN and ICLN programs, and aimed to evaluate the effects of such programs on awareness of infection prevention, guideline adherence and patient outcomes. Finally, we sought to identify gaps in the evidence base for ICLN networks, and opportunities for research.

METHODS

Scoping reviews are useful when available research is limited and heterogeneous in studies designs. They address broad questions and examine evidence regardless

of study design[18-21]. The improved five-stage methodological framework of Arksey and O'Malley was used to structure this study[18, 20]. This entails an iterative technique of formulating and redefining the research question, identifying relevant studies, selecting studies, charting of the data, and collation, summarization and reporting of the results. As suggested by Daudt and Colquhoun, a quality assessment of the included studies was also performed[19, 21].

After the initial review of the literature the following research question was developed to guide the review: What is known about ICLN programs and their effectiveness in raising awareness of infection control or in the improvement of infection prevention practices, and do these programs reduce the risk of healthcare-associated infections?

Ebsco/Cumulative Index for Nursing and Allied Health Literature (CINAHL) and PubMed were explored on 18 July 2017 for index terms and text words with the initial search term "link nurs*". Ebsco/CINAHL and PubMed were searched from inception up to 24 July 2017 (MD&JCFK). The following terms were used (including synonyms and closely related words) as index terms or free-text words: 'link' or 'liaison' or 'intermediary' and 'nurses' and 'infection control' or 'handwashing'. Google and Google Scholar were searched for grey literature on 25 November 2017 and 8 February 2018. The search was updated on the 25thSeptember 2018 (IJ&MD). The full search strategies for all resources can be found in the supplement. Duplicate articles were excluded. The following criteria for inclusion were adopted: research- and opinion-based papers, abstracts, reports and guidelines, published between 1980 and 2018, specifically on infection control link nurses, and focused on acute care hospitals. Papers could be in the English, Dutch, German or French language. Studies investigating link nurses not specific to infection control or studies describing role models, e.g. 'champions', that led implementation of infection control guidelines were excluded from this review.

We retrieved full text articles that fulfilled the inclusion criteria outlined above. Two reviewers (SW&MD, IJ&MD) independently selected eligible papers and hand-searched reference lists for additional papers. Inter-rater reliability was tested after screening titles/abstracts (Kappa = 0.6). Results were compared, and disagreements resolved by consensus. When full texts were not available, corresponding authors were contacted. Each step of the study selection was discussed within the study team.

Two team members (SW&MD, IJ&MD) independently extracted and charted data on a predefined data charting form on country, study design, setting, key findings, and outcomes relevant to our research question.

Themes emerging from the data were analyzed and discussed within the research team. Descriptive numerical and thematic analyses are presented as narrative summaries given the heterogeneity of the literature. This process followed the Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR)[22].

RESULTS

Initially, we identified 312 articles in PubMed and CINAHL and additionally 963 papers in Google and Google Scholar. After screening for title and abstract, 36 articles were considered potentially relevant, of which 26 met our criteria. Hand searching reference lists identified 9 additional studies, of which 2 were included. One article was included after the last search update. In total 29 papers were included (Figure I).

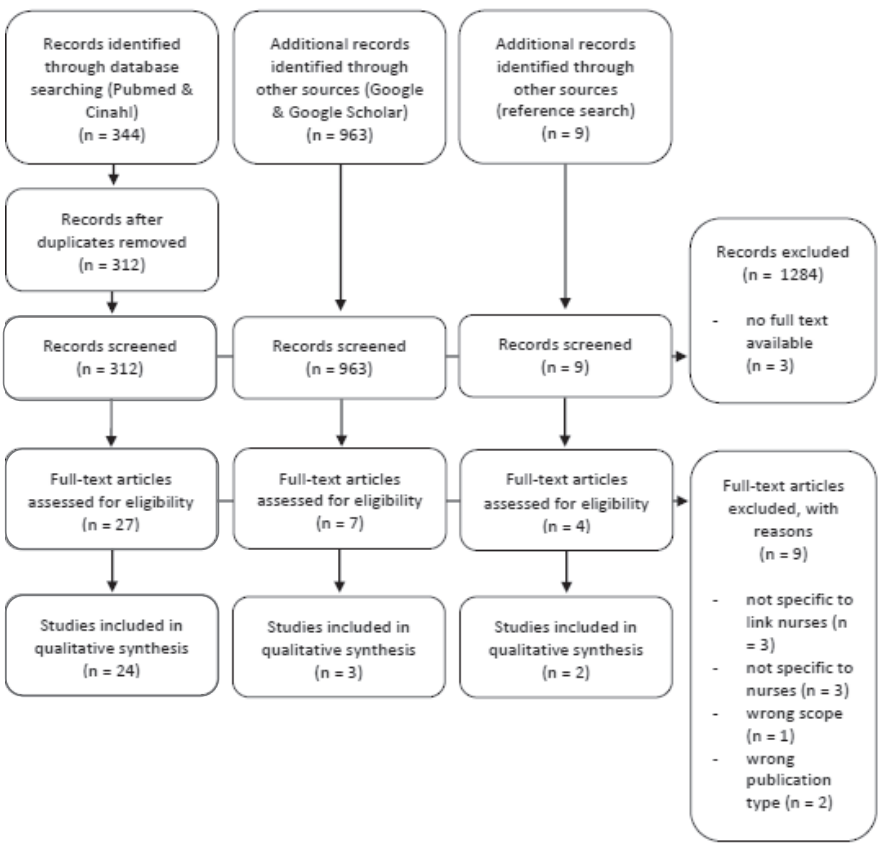

Figure I PRISMA flow diagram

The 29 included articles, 27 of which were peer reviewed papers, one guideline and one report represent literature from 5 continents. The majority of studies originated from the UK (n=14). The other studies were conducted in the USA (n=3), Australia (n=2), China (n=2), Japan (n=2), Germany (n=2), the Netherlands (n=1), Egypt (n=1), and Canada (n=1). Belgian and UK researchers collaborated on one abstract. Most studies had a descriptive design (n=12) or were before-after comparisons (n=7). Other studies included qualitative studies (n=4), cross sectional surveys (n=2), studies using action research (n=2), a mixed methods study (n=1), and a randomized controlled trial (n=1).

By charting the studies and summarizing the findings we identified that part of the studies focused on three major themes: the profile of ICLN, the implementation of ICLN programs, and strategies to support ICLN. The other part of the publications focused on outcomes of strategies that involve ICLN. Table I provides the details of studies including methodological comments and limitations of individual studies.

Table I Summary of included studies

Author details & Location	Study design	Setting	Key findings & Outcomes	Methodological comments & limitations
Braekeveld (2016) UK & Belgium	Abstract – interactive workshop and questionnaire on perception on the role of link nurses in infection prevention	450 voluntarily participants (link nurses, nurses, head nurses and infection control practitioners) in the UK and Belgium	A joint professional profile for infection control link nurses will follow	
Ching (1990) China	Cluster randomized controlled trial – introduction of a guideline for catheter care	1000 bed hospital in Hong Kong - Control group: three wards (surgical medical and gynecology) Test group: twenty-four wards	Three specific standards for urinary catheter care were significantly improved by link nurses educating their peers. Incorrect practices before intervention: - 63% intervention group - 68% control group ($p = 0.4$) Incorrect practices 5 weeks after intervention: - 36% intervention group - 48 % control group ($p < 0.05$)	One hospital One baseline measurement No follow up Differing numbers in control and intervention wards (sampling bias)

Author details & Location	Study design	Setting	Key findings & Outcomes	Methodological comments & limitations
Cooper (2001) UK	Descriptive paper- outline of the educational theory that underpinned infection control link nurses' education	-	Education of ICLN should be based on educational theories.	
Cooper (2004) UK	Descriptive paper - prologue of action research study	A district general hospital	Methodological considerations and argumentation for action research.	
Cooper (2004) UK	Action research	A district general hospital - fourteen wards	Three out of four barriers for compliance with hand hygiene were significantly improved 3 months after intervention in 14 clinical areas	Small sample size No follow up
Cooper (2005) UK	Qualitative research - Focus group	Ten ICLN	ICLN reported increased feelings of empowerment, ownership and motivation during one focus group with 10 link nurses	No information on topic list, non- participants, number of data coders, data saturation, member check
Dawson (2003) UK	Narrative review - outline of the role of the ICLN	-	ICLN have a role in surveillance and education or peers. The role of the ICLN is still evolving. In 59% of National Health Services Trusts link nurses are active.	
Graaf de (2013) Neth-erlands	Descriptive paper – outline of the appointment of 8 link nurses to support the infection prevention and control team in a Dutch hospital	One hospital 8 link nurses	As a result of an outbreak 8 nurses were appointed ICLN They support the infection and prevention and control unit for 8 hours a week and their departments are financially compensated	
Horton (1988) UK	Descriptive paper - outline of a pilot course	Sixteen ICLN in various services of a NHS trust	Monitoring performance of participants is crucial to the maintenance of high standards	

Author details & Location	Study design	Setting	Key findings & Outcomes	Methodological comments & limitations
Jacobsen (1999) Australia	Descriptive paper –outline of an educational program / implementation strategy	560 bed adult teaching hospital - Operating Theatre	Isolation of the OT can make it more difficult for the ICN to encourage changes in infection control practice. ICLN can help to overcome this difficulty. Monitoring tools are necessary for long-term evaluation	-
Macduff (2009) UK	Full report - Evaluation of Cleanliness Champions Program using a mix of qualitative and quantitative methods	NHS health facilities in Scotland	Program has substantive positive influence on the prevention and control of health care associated infections in Scotland	No process or outcome measures (as guideline adherence or Healthcare Associated Infection rates stated) Perceived impact stated
Manley (2012) UK	NICE guideline - based on two workshops analyzed by an approach termed concept analysis	-	A national role profile and core competences to support link practitioners, their managers or organizations with a ICLN network	Consensus based guideline
Lene (2002) Australia	Descriptive paper – outline of structure and developments of a link program	A general acute care hospital	A program requires dedicated coordination, flexible and well planned education and effective support from management	
Lloyd-Smith (2014) Canada	Implementation of link nurse program, focus group & economic estimate evaluation	Three acute care hospitals - 16 clinical units 8 with link nurses 8 without link nurse	Seven link nurses produced an action plan. 10 focus groups with stakeholders led to 5 themes for a successful program Key factor is effective monitoring of effectiveness and sustainability The program was cost effective. (cost for link nurse program per bed ($490) vs cost for extra infection prevention practitioner per bed ($596))	Convenience sampling, no information on data saturation, no member check are risks for bias Important and relevant costs and consequences for each alternative were not identified

Author details & Location	Study design	Setting	Key findings & Outcomes	Methodological comments & limitations
Millward (1993) UK	Cross-sectional - Audit tool & knowledge questionnaire	Three districts' health authorities. One location with link nurse program.	Audits on eight infection control topics for 20 wards. Wards with infection control link nurses obtained higher scores on compliance with infection control standards (p= 0.0006). Link nurse showed higher scores on knowledge (69%) than non-link nurses (52%) (p=0.008).	Sample sizes too small for analyses.
Miyachi (2007) Japan	Quasi experimental design	A 1133-bed University hospital	Significant decrease of monthly MRSA rates (from 6.3% to 5.0%) after implementation of link nurse system and during 2 year follow-up. Increase in monthly use of hand soap (17.3%).	As stated in article, risk of regression to the mean, maturation effects and confounding
Ross (1981) USA	Pre-post imple-mentation study - establishing of ICLN on patient units	A 650-bed, university-affiliated general hospital	Implementation of ICLN and determination of health care associated infections rates in years one. Year two monitoring infection rates. Education met expectations of link nurses (96%). In 9 of 11 wards rates were reduced.	No baseline, no follow-up data.
Seto (2013) China	Before – after study & participatory action	A private 850-bed institution	Involving ICLN in brainstorm sessions, poster competition, identification of points of care and monitoring compliance improved hand hygiene practice significantly from 50% to 83%. Use of hand rub increased from 8.1 liter/1000 patient days to 9.1 liter/1000 patient days.	Single centered uncontrolled study , maturation effects

Author details & Location	Study design	Setting	Key findings & Outcomes	Methodological comments & limitations
Shabam (2012) Egypt	Cross-sectional survey	Twenty hospitals, 205 head nurses who work as a ICLN in various departments (medical, surgical, neonatal, pediatric, obstetrics, gynecology, dialysis, outpatients' clinics, emergency, burn and urology)	Survey results showed that ICLN have a role in education (25%), consultation (25%) , administration (90%), research (21%) and supervision of safe practice (99%) The majority of head nurses participated in a training program related to infection prevention and control but not on their ICLN roles 48% of head nurses never performed ICLN roles. 54% had a low level of knowledge on infection prevention and control 79% had a high perception of infection prevention and control When head nurses' knowledge and perception increased the performances on the 5 identified roles increased (p = 0.0001)	No description or definition of "perception as a link of infection control"
Sopirala (2014) USA	Quality improvement study (pre-post design)	A 1191-bed University Medical Center	After a 2 year baseline period link nurses were introduced during a year. In that year MRSA rates reduced (28%, p=<0.01), MRSA bacteremia rates reduced (41%, p=0.003), hand soap consumption increased(from 19 to 31 ounces) as compliance with hand hygiene (from 30% to 93%).	No randomization, no follow-up
Sopirala (2018) USA	Before – after study evaluating a CAUTI prevention program with two different CAUTI definitions	A 699-bed tertiary care academic medical center	After a 21 month baseline period (data on urine cultures of 5 ICU units) link nurses were trained in CAUTI prevention, participated in training of colleagues and patients, and committed to ward based actions. CAUTI rates declined in with new definition (IRR 0.67, 95% CI [0.48-0.93]) CAUTI rates increased with old definition (IRR 1.12, 95% CI [0.88-1.43])	Single centered study, no follow-up

Author details & Location	Study design	Setting	Key findings & Outcomes	Methodological comments & limitations
Teare (1996) UK	Interventions study - outlining how to design the ICLN network for the hospital	District general hospital	Implementation in 3 phases: set up, setting standards on wards, management ownership. Infection control practices were divided in 8 areas. ICLN (n=51) had a role in education of peers and the audit of infection control practices. The link nurse system had a positive effect on clinical practices. Infection rates did not reduce. The infection control team was added to the trusts risk management group.	No baseline measurements, no follow-up. No exact numbers given.
Teare (1998) UK	Descriptive paper - reporting experiences and encountered benefits	Mid-Essex trust	Link nurses have a role in education and surveillance. ICLN system has raised awareness and increased the profile for infection control.	
Teare (2001) UK	Descriptive paper - outlining a study day for ICLN	Mid-Essex trust	Six interactive sessions on infection prevention knowledge and governance. A questionnaire quantified the self-assessed results of ICLN on their wards. This assessment of capabilities and limitations may be useful in the communication with ward management .	
Tebest (2017) Germany	Cross-sectional survey among ICLN (n=64)	University hospital	Response rate 29% (n=29). Intended services were rarely performed Barriers were the lack of release from other duties and the lack of acceptance of the role by physicians	One hospital Small sample

Author details & Location	Study design	Setting	Key findings & Outcomes	Methodological comments & limitations
Tsuchida (2007) Japan	An intervention study with before and after comparison	560-bed acute hospital located in a major urban area in Japan	In year one risk factors for CLABSI in catheter care were identified with the help of 4 link nurses. In the following 2 years interventions were implemented. ICLN educated colleagues and observed catheter care. In those two years CLABSI rates declined from 4.0/1000 catheter days to 1.1/1000 catheter days ($p<0.005$)	Single centered study, No randomization, no follow-up
Ward (2016) UK	Descriptive paper outlining the role of the link nurse	-	Currently there is limited evidence of the efficacy of ICLN in improving practice	
Wilbrandt (2001) Germany	prospective controlled study	Eight hospitals – four intervention and four controls	The concept of link nurses was introduced successfully. Improvements on the level of process quality (increase of contact moments between INLN and infection control staff) . No reduction of nosocomial infections.	No randomination Unclear duration of follow –up No definition for 'success' of the link nurses
Wright (2002) USA	Pre-post implementation observational study	A 87-bed neonatal intensive care unit at a Children's hospital	Decrease of nosocomial infections The role of the ICLN is flexible and can be tailored to the specific needs	No N, percentage or 95%CI stated

Key features

The profile of ICLN

Nine articles highlighted the ICLN profile with accompanying roles, tasks and competences[5, 6, 9, 13, 15, 23-26] using different terminology (e.g. roles vs tasks). ICLN were first described in 1981 as a liaison between the epidemiology department and clinical wards[9]. In the following years, the educational role was added[5, 14, 25]. The Royal College of Nursing published a national ICNL role profile for the UK in 2012. Four core themes were identified for the link nurse role: "act as a role model and visible advocate, enable individuals and teams to learn and develop infection prevention and control practice, act as a local communicator, and support in audit and surveillance"[12].

Tasks of the link nurse role that were considered viable included: perform surveillance of infections[9, 13, 15, 25, 26], monitor infection prevention and control practices[5, 9, 13], aid in the early detection of outbreaks of infection[5, 15, 26], improve clinical practice at ward level[5, 6, 13, 15, 23, 26], act as a role model[6, 23, 27], and assist in research[13, 26]. The task of transferring information to peers and other healthcare staff is described in five articles[5, 13, 23, 25, 26]. One article states that the influence of ICLN might lay more in improving practice than in the dissemination of knowledge upon which these practices are based[5].

The core competences of ICNL for fulfilling these roles and tasks include: receptive for feedback, proactive, non-judgmental, approachable, resilient, authoritative, assertive and charismatic[5, 15, 24, 27]. Two out of five studies that describe the enrollment of ICLN stress the importance of voluntary registration. It is seen as an expression of motivation and enthusiasm for infection prevention and control, which are perceived as core competences for the uptake of the ICLN role[5, 23-25, 28]. Authority is perceived as essential for carrying out the role. Therefore clinically experienced nurses are preferred as ICLN[5, 24, 27]. The Royal College of Nursing summarized competences of ICLN as: "to be passionate about infection prevention and control, responsible for own actions, an active participant in the ICLN network, approachable, non-judgmental, inclusive, reflective, and respectful"[12].

Implementation of ICLN programs

Five papers describe operational barriers of implementing an ICLN program[5, 11, 16, 24, 29, 30]. Two papers report on ICLN programs that discontinued due to operational difficulties[5, 16]. ICLN struggle with low staffing and high workload leaving insufficient time for ICLN activities[5, 11, 24, 29, 30]. High staff turnover challenges hospitals to keep the number of trained ICLN up to standard[5, 24]. To overcome these operational barriers an ICLN program in a Dutch hospital was set up with only eight ICLN. These ICLN were exempted from duty eight hours a week in order to propagate infection control practices at the ward and hospital level[23].

The difficulties encountered by ICLN in their educational role are discussed in six studies[15, 24, 29-32]. Two studies noted that medical staff lacked acceptance of the role of the ICLN or the need for infection prevention and control practice[29, 30]. Jacobsen reports a lack of participation of medical staff in educational sessions by ICLN[32].

Three papers describe the presence of ICLN as a risk. Although visibility of ICLN in their role is perceived essential to trigger behavioral change, other health care workers may foster the idea that infection prevention and control is not their concern and rely on the ICLN for all infection prevention and control matters[15, 24, 31]. None of the studies provided clues or insights in what aspects of ICLN programs were most effective.

Strategies to support ICLN

Strategies to support ICLN were listed in 17 papers and include education, commitment and coordination by the infection prevention and control team, support from ward management, support from the senior hospital management, and support between ICLN themselves[5-11, 14, 23-25, 27-29, 31, 33, 34]. Thirteen studies report on educational components of ICLN programs[5, 7-11, 14, 23, 24, 27, 28, 31, 34]. The Scottish Government provides a national training to aid education[34]. Twelve studies report on a local educational program under the direction of the infection prevention and control team[5, 7-11, 14, 23, 24, 27, 28, 31]. It is advocated to underpin this program with theory on adult learning[31], engage in active learning forms[5], communicate on topics of interest prompted by ICLN themselves[7, 31] and to communicate on one topic per year to create focus[27]. There is a large variation in the content of these programs. The curricula include content related to knowledge of microbiology, modes of transmission, nosocomial infections, and infection prevention and control policies, the application of this knowledge in nursing practice, education in auditing and surveillance, and skills for the dissemination of this knowledge to peers[5, 10, 14, 23, 24, 31]. The latter is perceived as vital for ICLN to become effective role models[5, 14, 31]. In order to expand these skills experts (e.g. a psychologist) contributed to two programs to tutor on leadership and change-management skills[10, 24]. Four studies suggest an introduction course (range 1-10 days)[5, 7, 9, 10]. This introduction course could be given as e-learning, to permit ICLN to start their activities at any time at their own pace[5]. Four studies report on regular meetings with one to three months intervals[7, 10, 14, 27]. Education modes vary from interactive sessions[7, 14], lectures, tutorials[28] and visits to the Microbiology Laboratory[7], laundry services and sterile processing department[10],to self-learning packages[11] and sharing copies of relevant literature[29]. Lectures are repeated several times[7, 28] or held during (a provided) lunch to facilitate attendance[7, 15]. Support by the infection prevention and control team is described in five studies[6, 7, 10, 24, 25]. Supporting activities include providing ICLN promotional and educational materials[24], through newsletters, and by mentoring the ICLN through regular ward visits for the discussion of progress and current ward-based problems [7, 10]. Action research or brainstorm sessions are used to collaborate in research, for the development of an implementation program and for ward-based action plans or assignments[6-8, 10, 24].

Three studies describe the role of the ward management in the empowerment of ICLN in fulfilling their role[5, 9, 29]. This support can be promoted by referring other staff to ICLN, by scheduling infection prevention and control topics for discussion at ward meetings, and by allowing ICLN training time[5, 29]. Support of senior ward management is described in three studies as enabling factor for the program as a whole[24, 25, 31]. Three studies describe networking between ICLN as a support mechanism. To create mutual communication, discussion and sharing of experiences with other ICLN is encouraged in regular meetings[24, 29, 33].

The effect of ICLN programs

Five studies have evaluated the introduction of ICLN with respect to infection rates[7, 8, 26, 35, 36]. Two studies with a before-after design and one with a quasi-experimental design showed that the introduction of ICLN led to improved compliance with hand hygiene or increased hand soap / sanitizer consumption and a reduction of Methicillin-Resistant *Staphylococcus aureus* (MRSA) rates[7, 8, 35]. In two other studies ICLN achieved a reduction of CLABSI[36, 37]. In the USA the reduction of nosocomial infections in a neonatal intensive care unit was linked to the introduction of an ICLN[26].

In three studies clinical practices improved with the help of ICLN[28, 32, 38]. In a Hong Kong hospital ICLN improved the care for urinary catheters in a cluster randomized controlled trial. The second study demonstrated higher compliance rates with infection prevention policies on wards with ICLN[38]. The third study described improved compliance with standard precautions in an operating theatre with an ICLN. The role of the ICLN was perceived pivotal. Compliance was not reported on[32]. One paper described a positive effect of "raising the profile for infection prevention and control"[15]. Another study reported a perceived improvement of infection prevention and control practice[27]. Furthermore one study reported "an improvement at the level of process quality" in a general sense after the implementation of ICLN[33].

DISCUSSION

This scoping review revealed a lack of research evidence on the effects of infection control link nurses on guideline adherence and patient outcomes. The majority of included papers delineate the ICLN profile with accompanying roles, tasks and strategies to support ICLN without an evaluation of the implementation process or effects in clinical practice. Only two of these articles included a brief evaluation of the impact of their ICLN program on healthcare-associated infections[9, 26]. Therefore the value and impact of ICLN programs is difficult to assess[5, 39]. Studies that report on the effect of ICLN programs in terms of patient outcomes or guideline adherence describe positive short term effects. Several ICLN programs appeared to have discontinued, none of these studies, however, mentioned that they did so because of negative or no results[5, 16].

Six of the studies that did report on the effect of ICLN programs had a single-center uncontrolled study design[7, 8, 26, 35, 36, 38]. These studies hold a high risk of selection bias[40]. Prevention of healthcare-associated infections may be influenced by many other factors than the ICLN program itself, and controlled studies may not find significant effects due to low statistical power (type II error)[41]. The combination

of study design and limited research output holds a risk for selective reporting of positive findings and publication bias. This might have influenced our findings.

The narrative synthesis is based on studies that vary in quality, design and outcome. We assessed study outcomes as having equal weight. Although standardized data extraction and an iterative team approach strengthened reliability, this may have led to bias in the categorization of our findings. Possibly, we missed relevant papers, since we chose to exclude studies on the role of champions and opinion leaders.

Although the quantity and quality of research on ICLN is limited, a common theme that emerges is that a number of factors are considered vital for the support of ICLN in the completion of their tasks. First of all educational programs are important. This is in line with previous findings that show that, to improve infection prevention practices education of health care workers is vital[42]. The content and delivery of education in ICLN programs is not standardized, but in general, education of ICLN by the infection prevention and control team to educate on infection prevention topics in regular meetings is considered best practice. This education can be extended by training in implementation skills by experts. With respect to how to set up educational meetings, focusing on one topic at each meeting is seen as important[27].

The ICLN profile is flexible and must be tailored to the local needs[5, 6, 39]. This is essential to facilitate nurses in the ownership of the ICLN role. A role profile clarifies expectations of ICLN for all stakeholders. It facilitates communication on the ICLN role and tasks within the organization[43].

Support by the management at ward level can empower ICLN to act as a role model and to disseminate knowledge to their peers. The adherence to guidelines will improve when management supports infection prevention and control measures[44] since this improves their leadership. De Bono *et al*. found an association between effective leadership and better adherence to infection prevention and control policies (e.g. hand hygiene and personal protective equipment)[45].

In the UK a generic role profile for ICLN is established by the Royal College of Nursing[12], but it is not clear in how many hospitals ICLN actually are appointed. ILCN are present in several hospitals throughout the Netherlands, but not everywhere[46]. In German acute care hospitals ILCN are mandatory[17]. Furthermore, link nurses have shown potential in other settings[47-51]. It is therefore justified to invest in further research.

There is a lack of studies that evaluate the process of implementation of ICLN and the outcomes of ICLN programs. Evaluation should consider how to tailor and deliver an ICLN program to maximize impact of link nurses on guideline adherence

and patient outcomes. By assessing in which context which program has impact, research findings can help to tailor ICLN programs to the local situation[52]. An in-depth description on how ward management, the infection prevention and control team and the ICLN interrelate can help understand how to support ICLN in fulfilling their tasks[53]. Damschroder et al. confirms the importance of cooperation between professionals from different disciplines to realize behavioral change[54]. Information on the perception of link nurses and their peers on the role and the perceived effectiveness of their effort can contribute to this in depth description.

Interdisciplinary collaboration in infection control networks may help overcome resistance of other health care workers[11, 54]. In this respect, studies focusing on how to involve other health care workers in general, and physicians in particular are needed .

Finally, there is a research gap in how to sustain ICLN programs, and on their economic value. For further research, we advocate the use of mixed method designs , since the implementation of an ICLN network can be considered a complex intervention. By measuring structure and process outcomes, the implementation of the intervention can be monitored and evaluated. Qualitative designs can help to understand and explain these findings and link them to the context in which the implementation took place[55].

CONCLUSION

There is a lack of robust evidence on the effectiveness of ICLN programs. Available studies have methodological issues, small sample size or lack the consideration of the implementation process or patient outcomes. This affects the transferability and generalizability of research findings. The impact of ICLN programs on patient outcomes is difficult to assess because these are influenced by many other factors. Therefore it is justified that future studies should focus on the effects of ICLN on surrogate end points such as awareness of healthcare-associated infections, knowledge of infection control, and guideline adherence. There is also a lack in the understanding of how ICLN can best be supported to disseminate knowledge and to create change sustainably. Future research on these support mechanisms and their contextual factors is needed to further develop ICLN programs for maximal impact.

SUPPLEMENTARY MATERIAL

Full search strategies for all resources

Scoping search

Search strategy for Ebsco/CINAHL (18 July 2017)

Search	Query	Items found
S1	TI "link nurs*" OR AB "link nurs*"	**133**

Systematic search

Search strategy for Ebsco/CINAHL (24 July 2017)

MH = keywords
+ = keyword with explosion
TI = words in title
AB = words in abstract

Search	Query	Items found
S9	S4 OR S6 OR S8	**102**
S8	S1 AND S2 AND S7	**46**
S7	MH "Infection Preventionists" OR TI((infection* OR cleanliness) N3 champion*) OR AB((infection* OR cleanliness) N3 (champion* OR preventionist*)	**1,736**
S6	S3 AND S5	**19**
S5	MH "Nurse Liaison"	**709**
S4	S1 AND S2 AND S3	**91**
S3	MH "Infection Control+" OR MH "Handwashing+" OR TI("infection prevention*" OR "infection control*" OR "crossinfection prevention*" OR "crossinfection control*" OR icln OR ipc OR handwash* OR hand wash* OR "hand hygien*" OR handhygien* OR disinfecti* OR "co wash*") OR AB("infection prevention*" OR "infection control*" OR "crossinfection prevention*" OR "crossinfection control*" OR icln OR ipc OR OR handwash* OR hand wash* OR "hand hygien*" OR handhygien* OR disinfecti* OR "co wash*")	**49,477**
S2	TI(intermediair* OR liaison* OR link OR links) OR AB(intermediair* OR liaison* OR link OR links)	**26,316**
S1	MH "Nurses+" OR MH "Nurses by Educational Level+" OR MH "Nurses by Role+" OR MH "Advanced Practice Nurses+" OR MH "Pediatric Nurse Practitioners+" OR MH "Nurse Practitioners+" OR MH "Nurses by Specialty+" OR MH "Nurses, Other+" OR MH "Nurse Administrators+" OR MH "Nurse Consultants+" OR TI(nurse*) OR AB(nurse*)	**332,963**

Search strategy for PubMed (24 July 2017)

[Mesh] = Medical subject headings
[tiab] = words in title OR abstract

Search	Query	Items found
#1	(("Nurses"[Mesh] OR "Nurse's Role"[Mesh] OR nurse*) AND (liaison*[tiab] OR intermediair*[tiab] OR link[tiab] OR links[tiab]) AND ("Infection Control"[Mesh] OR "Cross Infection/prevention and control"[Mesh] OR "Infection/prevention and control"[Mesh] OR "Hand Hygiene"[Mesh] OR infection preventi*[tiab] OR infection control*[tiab] OR crossinfection preventi*[tiab] OR crossinfection control*[tiab] OR hand hygien*[tiab] OR handhygien*[tiab] OR hand wash*[tiab] OR handwash*[tiab] OR disinfecti*[tiab] OR co wash*[tiab] OR infection prevention control*[tiab] OR infection prevention and control*[tiab] OR icln[tiab] OR ipc[tiab])) OR ((infection*[tiab] OR cleanliness[tiab]) AND champion*[tiab])	**232**

Search strategy for Google Scholar/Google 2 November 2017
("link nurse"|"link nurses") AND (~infection prevention|~infection control|~crossinfection prevention|~crossinfection control|icln|ipc|~handwashing|~hand washing|~hand hygiene|~handhygiene|~disinfection|~co washing)
Search strategy for Google Scholar 8 February 2018

German

(~liaison|~bindeglied) AND (~Krankenschwester|~pflegekräften|~hygienebeauftragten|~pfleger|~pflegerin) AND (~"infektion kontrolle"|~Kreuzinfektion|~Händewaschen|~Handhygiene|~desinfektion|~Infektionsverhütung|~Krankenhausinfektionen|~Desinfizieren)

French

(~liaison|~link) AND (~infirmiere|~championne) AND (~infection|~"laver les mains" |~hygieniste|~desinfection)

Dutch

(~aandachtsvelder|~contactpersonen|~kwaliteitsmedewerker) AND (~infectie|~infectiepreventie|~kruisinfecties|~"handen wassen"|~desinfectie) AND ~verpleegkundige AND ~ziekenhuis

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CHAPTER 3

Variation in and success factors of infection control link nurse programs in Dutch acute care hospitals; a mixed-methods study

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Infection control link nurse programs in Dutch acute care hospitals;
a mixed-methods study
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ABSTRACT

Background

Infection control link nurse programs show considerable variation. We report how Dutch link nurse programs are organized, how they progress, and how contextual factors may play a role in the execution of these programs.

Methods

This mixed-methods study combined a survey and semi-structured interviews with infection control practitioners, based on items of the Template for Intervention Description and Replication (TIDieR) checklist.

Results

The Netherlands has 74 hospitals; 72 infection control practitioners from 72 different hospitals participated in the survey. Four of these infection control practitioners participated in interviews. A link nurse program was present in 67% of the hospitals; responsibility for 76% of these programs lied solely with the infection prevention and control team. The core component of most programs (90%) was education. Programs that included education on infection prevention topics and training in implementation skills were perceived as more effective than programs without such education or programs where education included only infection prevention topics. The interviews illustrated that these programs were initiated by the infection prevention team with the intention to collaborate with other departments to improve practice. Content for these programs was created at the time of their implementation. Infection control practitioners varied in their ability to express program goals and to engage experts and key stakeholders.

Conclusion

Infection control link nurse programs vary in content and in set up. Programs with a clear educational content are viewed as more successful by the infection control practitioners that implement these programs.

BACKGROUND

Healthcare-associated infections are the most frequent adverse event for patients admitted to hospitals, and an important cause of morbidity and mortality[1, 2]. Careful infection prevention and control (IPC) measures can prevent up to a third of these infections[3]. IPC measures are laid down in guidelines and policies at the national and international level[2, 3]. Implementation of these guidelines is usually the task of infection prevention and control teams. In many Dutch hospitals these teams are supported by infection control link nurses (ICLN)[4]. In all countries were ICLN have been introduced, these nurses act as a link between colleagues in their own clinical area and the infection prevention and control team, and help raising awareness of infection control by educating colleagues and motivating staff to improve practice[4, 5].

Review of the literature on ICLN show that link nurse programs have been implemented all over the world. The majority of this literature originates from the United Kingdom and describes variation in how ICLN programs are organized and implemented[6]. This variation relates to all aspects of such programs - i.e. responsibilities and tasks of ICLN, activities for and education of ICLN, and competences that are required to fulfill the ICLN role[6-8]. The few studies that have evaluated effectiveness of these programs revealed that compliance with hand hygiene guidelines and incidence of MRSA infections indeed improve when ICLN are active[9, 10]. However, these studies do not describe their ICLN program in detail nor elaborate on the contextual factors that may have contributed to these improvements. Contextual factors include factors that are not part of the ICLN program such as cultural, organisational and management characteristics of the hosptial, but do play a role in the implementation of IPC practices[11, 12]. Examining the variation of existing ICLN programs, the assessment of contextual factors that have led to this variation and the evaluation of these programs can reveal opportunities to improve their value and to reduce their inefficiencies. We therefore aimed to describe how Dutch ICLN programs are organized and how they progress. Furthermore, we sought to explore the contextual factors that may have influenced the implementation of these programs.

METHODS

Study design

In a mixed-method study, we combined a cross-sectional survey with additional semi-structured interviews, based on items of the Template for Intervention Description and Replication (TIDieR) checklist[13]. The TIDieR checklist is an extension of the CONSORT 2010 and SPIRIT 2013 statement and was designed to guide the

description of trial interventions in sufficient detail to allow their replication. It has proven to be also applicable for reporting and evaluation of complex interventions in non-trial settings[14, 15]. The checklist consists of items concerning: the name of the intervention, the rationale, theory or goal of intervention elements, procedures; providers; how the intervention was delivered and where; the number of times the intervention was delivered and over what period of time if it was tailored, adapted or modified; and if fidelity was assessed.

To describe the Dutch ICLN programs we developed a survey. Survey questions were based on recent literature on ICLN and categorized according to the TIDieR checklist items[6, 16, 17]. The survey contained multiple choice questions, some with multiple answer options. Three infection control practitioners and an epidemiologist pilot tested the survey. After adjustments it was divided in five parts. The first part contained questions on the presence of an ICLN program or the intention to set up such a program. The second part zoomed in on tasks, goals, and activities of the link nurses. In the third part, infection control practitioners were asked which competences they consider important to fulfill the ICLN role. The fourth part covered the educational content and the evaluation of the program. In the final part, respondents were asked to what extent they were able to accomplish their IPC goals through the help of ICLN. This was expressed on a 10 point Likert scale.

Cotterill et al. recommended to describe how contextual factors may have influenced the execution of the intervention to compile a more realistic image of implementation in real life practice, and proposed to extend the TIDieR checklist by four items[18]. These items include the incorporation of the perspectives of those who provided the intervention, the stage of implementation (e.g. from proof of concept to long term sustainability) the intervention has reached, a description of adaptations made to any item in the checklist, and an outline of factors which had impact on how the intervention was implemented.

To explore how contextual factors had influenced implementation and to investigate the real life practice of ICLN programs, selected infection control practitioners were interviewed in a semi-structured way. The interviews allowed the additional exploration of personal views, experiences and perceptions on why and how specific components of the ICLN program were chosen, how the program was realized in practice, and how it changed over time[19, 20]. A topic list (Table I) based on the checklist extensions as described by Cotterill et al, guided the face to face interviews.

Table I Topic list

Topic list
1. Delineation of the ICLN program
o the start
o the goals
• what are the goals?
• what actions are necessary to achieve goals?
• how do you know if you have achieved a goal?
• what helps in achieving goals?
• what does not help?
o the plan
• where adjustments made to the plan?
• how would you know if adjustments are necessary?
2. Embedding of the program
• how do you secure continuity and effectiveness?
• what is the role of the infection control practitioners?
• what is the role of others?

Data collection

During a National Congress for Dutch infection control practitioners in April 2018, surveys were distributed to and collected from one infection control practitioner per Dutch hospital (n=74) with inpatient departments. One week after the congress, infection control practitioners who did not return their survey were contacted by telephone. To further explore survey answers, we conducted semi-structured interviews with infection control practitioners between July 2018 and October 2018. To explore multiple perspectives a purposeful sampling technique was applied[20, 21]. Selection of infection control practitioners was based on the duration of the program in their hospital and how the practitioner graded the effects of the program. The interviews were conducted by one researcher (MD). Interviewees were informed about the study goals, and that there were no right or wrong answers. They were assured anonymity and provided a written consent. The results of the interviews are reported according to the Consolidated Criteria for Reporting Qualitative Research checklist[22].

Data analysis

Surveys and interviews were analyzed separately. Subsequently, survey and interview outcomes were compared to integrate the findings[23].

Surveys were included in the analysis if ≥50% of questions were answered. Survey data were analyzed using descriptive statistics. Items that were identified as best practices in ICLN programs in previous studies were compared (6). These best practices are the availability of a written role profile, education on infection prevention topics as well as on implementation skills, and support of ICLN by the ward manager. Differences in median values for the achievement of program goals between groups were analyzed with the Mann-Whitney U test for comparison of

two groups and the Kruskal-Wallis test for comparison of three groups. A post-hoc test was performed with a Kruskal-Wallis test with Bonferroni correction for a pairwise comparison of the educational programs. A boxplot was created based on this comparison. Analyses were performed with R Studio version 5.0-0 (R Foundation for Statistical Computing, Vienna, Austria).

Interviews were audio recorded, transcribed verbatim (MD) and analyzed by thematic analyses with an iterative, inductive approach[24, 25]. Two team members (MD & RM) read the transcripts several times and independently coded the transcripts to reflect the underlying meaning of the text. Codes were compared and discussed to reach consensus on code names and meaning (MD, RM & IJ). A codebook was created. These codes were clustered into categories and ultimately into themes. During team meetings the influence of the researchers' backgrounds (Public and Occupational Health, Clinical Microbiology, and Infection Control) was reflected on to further enhance research rigor[26]. Transcripts were analyzed with Atlas.Ti software version 7.0 for Windows.

RESULTS

In total, 72 of 74 questionnaires were returned (response rate 97.3%)(supplementary material). Forty-eight (66.7%) came from hospitals with an ICLN program in place. Eighteen (25%) came from hospitals that were planning to implement such a program in the near future. Six (8.3%) reported the ceasing of their link nurse program due to lack of support from ward and hospital management (n=2), lack of time and power that was allotted to ICLN (n=3), or other hospital priorities (merger) (n=1). Nine Dutch synonyms were found for these programs. Participants completed all questions in 47 (65.7%) of 72 surveys. Each participant completed 50% or more of the questions; all surveys were included in the analysis. Four infection control practitioners were interviewed. Duration of the programs in these hospitals ranged from three to eight years. The interviewees graded the accomplishment of their goals thanks to the help of ICLN as four (n=1), six (n=2), and eight (n=1) on the 10-point Likert scale. The interviews lasted between 42 and 54 minutes.

From 523 initial codes, 62 categories and ultimately six themes were identified, four of these were linked to the survey results (Table II). Quotations are included for illustration.

Table II Survey results (n=48¥)

	Proportion (%) * Median (IQR)
Characteristics of ICLN programs	
Goals for the program and link nurses	
Increase awareness for infection prevention	46/48 (95.8)
Act as a role model and opinion leader	39/48 (81.3)
Disseminate knowledge on infection prevention	43/48 (89.6)
Act as a source of information for peers	44/48 (91.7)
Contribute to development of ward based infection prevention guidelines	24/48 (50)
Implement guidelines or improve adherence	40/48 (83.3)
Liaise between ward and infection prevention and control team	45/48 (93.8)
Qualities for link nurses to achieve program goals	
Enthusiastic	17/40 (42.5)
Motivated	33/40 (82.5)
Assertive	3/40 (7.5)
Persistent	6/40 (15)
Proactive	28/40 (70)
Natural leader	4/40 (10)
Approachable	15/40 (37.5)
Resilient	4/40 (10)
Responsible	15/40 (37.5)
Respectful	2/40 (5)
Preparation of ICLN programs	
Mode of selection of link nurses	
Nominated by the ward management	32/48 (66.7)
Designated by the ward management	29/48 (60.4)
Approached and invited by the infection prevention and control team	10/48 (20.8)
Voluntary registration	19/48 (39.6)
Recruited though an application procedure	1/48 (2.1)
Other modes of selection	2/48 (4.2)
Health Care Workers involved	
Nurses	47/48 (97.9)
Physicians	1/48 (2.1)
Other HCW (e.g. surgical assistants, physiotherapists, laboratory technicians)	30/48 (62.5)
Departments involved	
Inpatients Wards	47/48 (97.9)
Outpatients Clinics	36/48 (75)

	Proportion (%) * Median (IQR)
Diagnostics – Day care	38/48 (79.2)
Other departments (e.g. laboratories, operating theatre, facility services)	30/48 (62.5)
Education of ICLN	
Educational program (yes)	42/48 (87.5)
Number of training sessions and meetings per year	
< 4	20/40 (50)
4	14/40 (35)
5	4/40 (10)
6	2/40 (5)
Duration of training sessions or meetings (in hours)	2 (1.4 – 3.3) *
Modes of education	
Introduction course	
provided by an external party	6/42 (14.3)
an in-house introduction program	24/42 (50)
e-learning	4/42 (9.5)
Regular training/education	
lectures	32/42 (76.2)
skills training	21/42 (50)
simulation based learning	3/42 (7.1)
hospital tours and visits	8/42 (19)
brainstorm sessions	11/42 (26.2)
group discussion/meeting	27/42 (64.3)
teambuilding sessions	3/42 (7.1)
Training and education of link nurses	
Developed by the infection prevention and control team	32/40 (80)
Developed in collaboration with experts (e.g. microbiologists, education experts)	8/40 (20)
Topics for training and education	
Selected by the infection prevention and control team	14/38 (36.8)
Determined by link nurses and the infection prevention and control team	23/38 (60.5)
Topics for education and training	
Planned out in an annual plan	7/35 (20)
Depend on occurring events	28/35 (80)
Responsible for the link nurse program	
Mainly one infection control practitioner	23/45 (51.1)
The infection prevention and control team	11/45 (24.4)

	Proportion (%) * Median (IQR)
Share the responsibility with other departments	17/44 (38.6)
Evaluation of ICLN programs	
Evaluation	23/45 (51.1)
Based on	
satisfaction with the program by link nurses and other stakeholders	15/22 (68.2)
compliance with guidelines in relation to the activities of the link nurses	6/23 (26.1)
prevalence of Nosocomial infections in relation to the activities of the link nurses	2/23 (8.7)
other	6/23 (26.1)
Effects of Infection control link nurse programs	
No effect	2/20 (10)
Positive effects	17/20 (85)
Positive and negative effects	1/20 (5)

¥ *not every question was answered by all respondents, therefore denominators vary*

The start of ICLN programs

In all hospitals where the infection control team initiated an ICLN program, the initiative for the program originated from their need to collaborate with other departments in the hospital, and from the need to disseminate practical IPC knowledge. The actual start of these programs was related to a more positive overall attitude of hospital management and health care workers towards IPC; it was sparked by threats such as a recent Ebola outbreak and the rise of antimicrobial resistance. The occurrence of outbreaks of resistant strains in hospitals, and pressure from external bodies (e.g. Joint Commission International) increased the urge for hospital management to address IPC as an integral part of patient safety and quality of care. It created opportunities for support for infection control practitioners to start an ICLN program.

> we needed this outbreak of vancomycin-resistant enterococci to convince our hospital management that we needed to implement an ICLN program [interview 4]

In the first phase of setting up a program, the infection control practitioners pitched and discussed their ideas with middle and higher management.

> I have been to all wards and talked to the management...we were preparing our hospital for a JCI accreditation [interview 1]

The characteristics of ICLN programs

Infection control practitioners aimed to build a structural relationship with the link nurses in order to exchange information on IPC practices and to improve compliance with IPC protocols.

> I hope to learn each link nurse to detect potential infection prevention risks… that they will contact me when they have detected a risk or when they have an IPC related question… I want to team up with these nurses [interview 4]

The top three goals of ICLN programs were to increase awareness for infection prevention, to create a liaison between the wards and the IPC team, and to make ICLN a source of information for their peers. Some infection control practitioners were able to described these program goals in a clear manner and incorporated knowledge and skills from other departments (e.g. quality department, training and education department) to supplement their own and ICLN' competences whereas others found it challenging to prepare a plan of action.

> as an infection control practitioner I am obliged to support link nurses, but I don't know how to do that best [interview 2]

To achieve the program goals, the most sought qualities for ICLN were being motivated, proactive, and enthusiastic. Infection control practitioners' views on the interaction with the ICLN and communication in the context of the ICLN program varied. Some infection control practitioners focused their efforts on providing support for the ICLN in implementing IPC policies, where others focused more on receiving support from the ICLN in monitoring the compliance with IPC measures.

> you need to listen to the needs of your link nurses…I want to serve them and support them to disseminate their knowledge to their peers on the wards [interview 3]

The preparation of ICLN programs

Most ICLN were nominated by the ward management; clinical experience as a health care worker was not considered necessary. Not only nurses were included, in most hospitals other disciplines and departments also participated. In one hospital physicians were involved. Infection control practitioners described that they developed their programs while implementing them at the same time. Programs were adapted as IPC teams searched for an optimum strategy to collaborate with their link nurses to improve practice. Adjustments to the program

were based on lessons learned during implementation and the dynamic IPC priorities. Infection control practitioners query what sort of training to provide, what topics to educate on and how to stimulate ICLN to be proactive.

> Our link nurse meetings must become a bit more interactive. We need to ask: "What did you learn? What will you do differently tomorrow? What is the next issue you will address?" [interview 3]

The education of ICLN

In almost 90% of the hospitals, programs for ICLN included education, given in sessions with a median duration of two hours, at a frequency of one to six sessions per year. Education of ICLN was generally shaped as in-house training and started with an introduction course. Responsibility to achieve the ICLN program goals lied solely with the IPC team in two thirds of the hospitals.

The IPC teams perceived the introduction of ICLN networks and the activities of ICLN as important assets that helped them to achieve their infection control goals. They scored this importance with a median of 7.0 (IQR 6.0-7.0) on a 10-point Likert scale.

Table III displays best practices in ICLN programs and how participants perceived the role of these best-practices in achieving their program goals. In 72% of the hospitals a written role profile was available. The median value for the perceived accomplishment of programs goals for these hospitals did not differ from hospitals that did not provide a written role profile. Seventy-one percent of infection control practitioners reported support from ward management for ICLN in their hospital. The median value for perceived accomplishment of programs goals also did not differ when compared to programs that did not report this support. ICLN programs that included education on infection prevention topics and training in implementation skills were perceived as more effective (median 7.0, IQR 7.0-8.0) than programs without such education (median 5.0, IQR 2.5-6.8) or programs where education included only infection prevention topics (median 6.0, IQR 6.9-7.5) (Table IV) (Figure I).

Table III Comparison of best practices for ICLN programs with perceived accomplishment of program goals

Survey item	Proportion (%)	perceived accomplishment of program goals (range 1 – 10) (n=48) Median (IQR)	p - value
Written role profile			0.22†
Yes	34/47 (72.3)	7.0 (6.0 - 8.0)	
No	8 /47 (17.4)	6.0 (6.0 - 8.0)	
don't know	5/47 (10.6)	6.5 (6.0 - 8.0)	
Education			0.02†
No education	6/48 (12.5)	5.0 (2,5 - 6.8)	
Education on infection prevention topics	21/48(43.8)	6.0 (6.0 - 7.5)	
Education on infection prevention topics and training in implementation skills	21/48 (43.8)	7.0 (7.0 - 8.0)	
Support			0,09‡
Support of ICLN by ward management	32/45 (71.1)	7 (6.0 - 8.0)	
No support of ICLN by ward management	*13/45 (28.9)*	*6 (6.0 - 7.0)*	

† *Mann-Whitney U test,* ‡ *Kruskal-Wallis test*

Table IV Comparison of the educational programs with perceived accomplishment of program goals

Education	perceived accomplishment of program goals (range 1 – 10) Adjusted p - value§	
	(0)	*(1)*
(0) No education program	-	
(1) Education on infection prevention topic	0.24	-
(2) Education on infection prevention topics as well as training in implementation skills	0.03	0.41

§ Kruskal-Wallis test with Bonferroni correction for a pairwise comparison

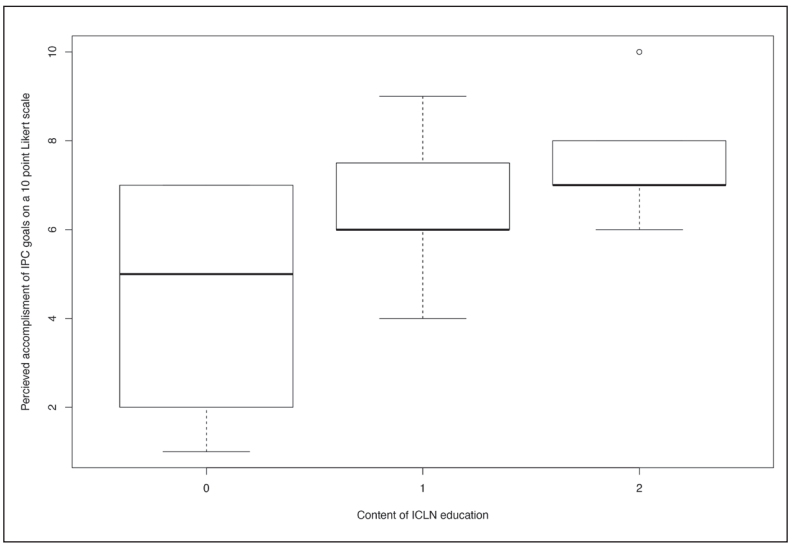

Figure I Median perceived effects of educational programs
0= no education 1= education on infection prevention topics 2= education on infection prevention topics and training in implementation skills

The progression of ICLN programs

To better support link nurses with department-specific questions or projects, some infection control practitioners scheduled regular meetings at the department in addition to, or instead of, the hospital wide educational meetings. Furthermore, some infection control practitioners involved ward management in ward-specific ICLN activities to interweave the hierarchical structures with the ICLN program activities. This enabled them to influence both the formal and the informal network to facilitate the program goals and created the opportunity to generate more ward-based support for the ICLN. In parallel, it created an opportunity to increase engagement of other infection control practitioners with the program. Occasionally, meeting attendance by ICLN was registered and reported to the management.

> at the start of this program ICLN educational meetings were mandatory… at that time, we were in the middle of an outbreak, we didn't have enough time to educate our link nurses… nowadays we do not educate in central meetings, we leave it up to the individual IPC team members to maintain intensive contact with their wards and their link nurses. Each Infection control practitioner is responsible for their own contacts and for what is going on in those departments [interview 4]

Infection control practitioners described the challenge to develop a program that interconnects ICLN of various departments, to create opportunities for ICLN to exchange experiences and ideas. The variation in work environment and training background is considered to cause this lack of interaction between ICLN of different departments.

> we initially wanted to bring link nurses from clinical wards and outpatient clinics together …. during the training it turned out that there was a big difference in knowledge between those two groups…. and that did not correspond so well. They were not able to have meaningful discussions [interview 4]

The limited time for IC tasks available for link nurses and for ICLN program tasks of the IPC team was mentioned as a barrier to the implementation of ICLN programs.

> last year we could not start the ICLN education for new link nurses …the time was allocated for general education of nurses on the new electronic patient files program [interview3]

The evaluation of ICLN programs

Half of the ICLN programs have been evaluated. Most evaluations (15/22) were based on the satisfaction of stakeholders with the program. Six hospitals evaluated their ICLN program in relation to the adherence to IPC guidelines. Two hospitals evaluated their program in relation to the prevalence of nosocomial infections.

The majority of hospitals that evaluated their program (17/20) reported positive effects. From the interviews arose the impression that these conclusions were based on random observations during ward rounds and gut feeling. Reported effects seemed related to practical issues (e.g. being able to find IPC protocols, stock management of personal protective equipment)

> Link nurses say that we are more visible … they know how to find us, they consult us. I think that is positive [interview3]

> I see more information leaflets on infection prevention topics in wards were a link nurse is active [interview 4]

DISCUSSION

This mixed methods study provides a detailed overview of infection control link nurse programs in the Netherlands and gives a broader understanding of the factors that can influence the content of these programs and their implementation in acute care hospitals. It confirms the well-known variation in these programs. In addition, our approach permitted us to quantify this variation, and to find opportunities to reduce inefficiencies and to improve the value of these programs. This, to the best of our knowledge was not done before.

Two thirds of Dutch hospitals have an ICLN program in place. Although programs vary widely, education is a core component of nearly all of these programs. ICLN programs are often set up and led solely by the IPC team. Our survey showed that infection control practitioners were more satisfied with their ICLN program if they were able to incorporate training in implementation skills in their educational program. From the interviews it transpired that infection control practitioners seemed more satisfied if they were able 1) to express a more coherent vision and more long term strategic goals 2) to involve more experts (e.g. educational experts) in the enhancement of their program and 3) to engage more key stakeholders, including management, and their direct colleagues, the IPC team, to create support. These aspects therefore, appear useful to keep in mind when planning improvements of existing ICLN programs or when setting up new programs. Overall, our results emphasize that to improve the ICLN programs, infection control practitioners need to have sufficient skills to select and apply appropriate implementation strategies, and to evaluate these strategies to continuously adapt to the dynamic hospital context. In line with this, Gilmartin and colleagues suggests that infection control practices can indeed improve if implementation strategies are systematically considered and applied[27]. The 2017 Geneva Think Tank, a panel of international experts, concluded that implementation science must be a priority in infection prevention[28]. In agreement with our findings it stresses the importance for infection prevention experts as well as other health care workers (e.g. ICLN) to improve their implementation skills.

Education of the link nurses is seen as the core element of ICLN programs although the effect was not systematically measured. Grol et al nicely summarized the evidence that shows that the dissemination of research findings or guidelines through education can be helpful to realize simple changes in daily practice[29]. However, to improve IPC guideline adherence behavioral change is a prerequisite and such change requires more complex strategies[29-31]. Considering our findings in the light of recommendations made by the World Health Organization, we suggest that ICLN programs should be designed as multimodal interventions[32]. The multimodal approach includes: (1) a comprehensive plan of education, training

and communication, (2) the engagement of hospital and ward management, and (3) audit and feedback[28, 32]. It is also important to understand the potential barriers for the implementation of an ICLN program to fit the program to the local context, and to be able to intervene to remove these barriers[29]. We agree with Cunningham et al, that to engage other stakeholders and to collaborate with direct colleagues can help in preventing vulnerability of the program with respect to sustaining network activities[33]. Audit and feedback is essential to boost implementation of IPC policies and can yield valuable input for the evaluation of effects of and refinements to the ICLN program[32, 34]. Finally, and possibly most importantly, ICLN programs should be considered as an integral component of infection prevention and control programs and not as a self-contained project[32].

A major strength of this study is the high survey response rate. It contributed to the representativeness of our findings. We performed additional interviews to deepen our insight in the findings from the survey. This triangulation reduced the chance of single source bias[35]. Furthermore, the interviews reflect real life strategies used by infection control practitioners to disseminate their knowledge through link nurse programs. A deeper understanding of the structure and characteristics of these programs is vital to further develop well-functioning programs[33].

This study has limitations. As the IPC community in the Netherlands is small, respondents might have chosen to respond in a more positive way than to choose the responses that reflected their true thoughts. This social desirability bias could distort the results in the survey and the interviews[36]. To decrease the chance for this bias we assured participants in the survey and in the interviews their anonymity; we also explicitly made it clear that there were no right or wrong responses[36].

The interviews were performed to ad real world examples from link nurse programs to the survey results; the number of interviews was small and therefore may have only provided a limited number of points of view. We provided interview quotes, to enhance transferability of our findings[37].

A follow-up study using social network analysis could operationalize the social structure and cohesion of ICLN networks, their relevance to the implementation of IPC guidelines and clarify how to improve network-based processes to transfer IPC knowledge and support program goals[38-40].

CONCLUSION

Infection control link nurse programs in Dutch hospitals originate from a need to collaborate with, and to disseminate practical IPC knowledge to other departments in the hospital. The start of these programs is related to a more positive overall attitude of hospital management and healthcare workers towards infection prevention and control. Although programs vary widely, education is an overall core component. Efforts to improve the uptake of IPC guidelines through ICLN programs should focus on enhancing infection control practitioners' and link nurses' knowledge on implementation science and designing these link nurse programs as multimodal interventions. To evaluate the contribution of ICLN programs to the implementation of IPC guidelines it is necessary to audit the program effects and to perform well-designed effectiveness studies. Social network analysis could contribute to understanding how knowledge on infection control and prevention is transferred best.

SUPPLEMENTARY MATERIAL Response rate

Response	n (%)
number of Dutch Acute Care hospitals	**79***
number locations excluded	
- locations without inpatient clinic	4
- location of research team	1
locations included	74
questionnaires filled out	72
locations covert in questionnaires	72/74 (97.3%)

* *Number of Dutch Acute Care Hospitals according to CBS*

https://www.volksgezondheidenzorg.info/onderwerp/ziekenhuiszorg/cijfers-context/aanbod#node-aantal-instellingen-voor-medisch-specialistische-zorg

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CHAPTER 4

Role perception and work requirements of infection control link nurses; a multi-center qualitative study

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Role perception of infection control link nurses; a multi-centre qualitative study
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ABSTRACT

Background

Infection control link nurses (ICLN) disseminate knowledge on infection prevention topics to their peers. Little is known about how they succeed and thereby contribute to infection prevention in daily practice.

Aim

To explore the experiences of infection control link nurses regarding their role in acute care hospitals and identify perceived facilitators and best practices.

Methods

We conducted a qualitative study with semi-structured individual and focus group interviews with ICLN. The effect of COVID-19 on the ICLN role was added as a topic in focus group interviews during the pandemic.

Results

Twenty-six ICLN working in acute care hospitals were interviewed. ICLN perceived their role as to identify, monitor, facilitate and inform their colleagues on infection prevention topics related to their ward. Their experiences vary from feeling challenged and wonder how to get started, to feeling confident and taking initiatives that lead to ward-based improvements. When inspired by each other and supported by infection control practitioners or managers, ICLN feel empowered to initiate more activities to improve practice. During the COVID-19 pandemic, ICLN felt their responsibilities were magnified. When transferred to another ward, the focus on the ICLN role seemed dispersed.

Discussion

Empowered ICLN adjust and operationalize infection prevention policies to fit the conditions of their specific wards and provide practical instructions and feedback to their peers which enables better compliance to infection prevention policies. Support and inspiration from other ICLN, infection control practitioners and management contribute to this empowerment and consequently to taking impactful initiatives to improve practice.

BACKGROUND

Infection control link nurses (ICLN) are role models in providing safe care and transfer their knowledge and skills to their peers[1]. In order to fulfil this role, link nurses in acute care hospitals are trained by infection control practitioners. Programs to support ICLN vary in the way they are organized from occasional education to well-designed programs that also provide training in implementation skills through train-the-trainer principles[2, 3]. Implementation of the link nurse role depends on local priorities; ad hoc practice is common[2, 3].

Prior studies have mainly focused on ICLN roles from an organizational perspective[2, 4]. Little is known about the way link nurses themselves perceive their role; how they fulfil it, how they increase and disseminate their knowledge, what difficulties they encounter, and what supports them in advocating infection prevention in clinical practice. The few studies that have assessed the ICLN perspective, focused on the ICLN profile with accompanying roles and tasks and on educational strategies[5-7]. In a qualitative study, experiences of ten ICLN with a six month ICLN program were evaluated, revealing self-reported empowerment and self-reported improvement of clinical practice[5]. Other papers provided suggestions for the education of link nurses, mechanisms to support them, and the legitimation of the role[6, 7].

Although these aspects deserve attention, they fail to help in understanding how ICLN endeavor to disseminate their knowledge and improve practice, and what hinders and facilitates them during their activities. Examining these issues could provide better insight in how ICLN contribute to the improvement of infection prevention at the ward level and how ICLN programs could optimally facilitate these contributions. We therefore sought to explore the experiences with and perceptions of ICLN regarding their role in acute care hospitals.

METHODS

Study design

Between April 2019 and December 2020, we conducted a qualitative study in which we combined face-to-face semi-structured interviews and online focus group interviews with ICLN from five Dutch hospitals. We followed the Consolidated Criteria for Reporting Qualitative Research[8].

Participant selection

To maximize variation in perspectives, we recruited ICLN from inpatient wards and outpatient clinics from three university hospitals and two general hospitals with varying ICLN programs. All ICLN practicing in inpatient and outpatient

settings were eligible to participate. They were invited to participate by email by the hospital's infection control practitioner. Twenty three ICLN responded and received an information letter about the aim and procedure of the study and the voluntary nature of the study.

Data collection

Semi-structured face-to-face interviews were performed to capture and understand personal views, opinions and experiences[9]. These interviews were conducted by three female researchers (MD, BS, TL) trained in qualitative methodologies and interview techniques. MD is an infection control practitioner and a clinical epidemiologist, TL is an infection control practitioner, BS is a fulltime researcher with a nursing background. Interviews took place between April 2 and June 25, 2019 at a convenient time in a private room at the participants' hospital. The researchers did not know the participants they interviewed.

An interview guide (table I) based on recent literature on ICLN was used[2, 3]. The interviews started with asking the ICLN to describe their role in general and to provide examples of their activities as an ICLN. Follow-up questions encouraged them to express their thoughts and perceptions more thoroughly. The interviews lasted between 29 and 54 minutes and were audio-recorded with the consent of the interviewees. Field notes on the interviews were documented by the interviewers directly after each interview. After 15 interviews, no new subjects came forward. We planned two extra interviews for checking data saturation, and no new themes emerged. Therefore, after 17 interviews data saturation was considered to have been reached[9].

During the course of this study, at the stage of data analysis, the COVID-19 pandemic evolved. We hypothesized that this exceptional situation could have influenced ICLNs perceptions on their role. Therefore, we included a topic related to the role of ICLN during the first wave of the recent COVID-19 pandemic and performed focus group interviews.

Focus group interviews were conducted using a digital platform (https://zoom.us/) in November and December 2020 and consisted of two to four participants. Three participants were not able to log in for the online focus group interviews due to technical problems (one participant) or patient care duties (two participants). A moderator (MD) led the discussion. An observer (IJ & JJ) took notes on striking topics or non-verbal communication and interaction. The researchers had no formal hierarchical relationship with the participants. Focus group interviews lasted between 42 and 65 minutes.

Table I Topic list

How did you take on the link nurse role?
Did you volunteer for the role or were you appointed?
What was the reason for signing up?
How would you describe the link nurse role?
How will others know that you are an ICLN?
Can you describe some recent link nurse activities?
Did these activities change over time?
What did change? And why?
○ What are plans for the future?
Would you have done things in a different way?
○ What would you have done different?
What would you need for that to do so?
Did you have to learn to be an ICLN?
Can you explain that?
How did you know what you had to learn?
Can you relate that to a moment, event or feeling?
What would help you need to fulfil your link nurse role?
What would be needed for that?
What if these needs cannot be fulfilled?
Did the current COVID-19 pandemic affect the link nurse role?
Can you explain that/describe your experiences?
Can you describe how it affected your link nurse activities?

Data analysis

The face-to-face interviews were transcribed verbatim by an independent professional transcriber, checked for accuracy by one researcher (MD), and analyzed using thematic analysis (10)]. The focus group interviews were transcribed by one researcher (MD). Two researchers independently (MD, TL) read the transcripts several times to familiarize with the data. The first eight interviews were independently coded by the two researchers by highlighting segments of text in the transcripts and coding these inductively. Differences in the interpretation of text segments or codes were discussed. As consensus was high, the remaining interviews were coded by one researcher (MD) and subsequently discussed by the research team (MD,RM,TL, BS & IJ). An audit trail, consisting of field notes on interviews, memos created during the coding process and annotations of research related discussions, helped to maintain awareness of the teams' preconceptions and how they could affect the interpretation of findings.

Initial codes were sorted and grouped into categories by one researcher (MD). Subsequent discussions with the research group (MD,RM,TL, BS & IJ) aimed to refine categories and define overarching themes. From the initial 1305 codes, we created 36 categories and three overarching themes. The analysis of the focus group interviews revealed three additional codes. Themes, categories and codes were again reviewed by MD, RM, IJ to improve the quality of the analysis. One researcher (MD) further refined the themes and described the content.
All data was analyzed in Atlas.Ti software version 8.0 for Windows.

RESULTS

Twenty-six link nurses were interviewed: seventeen link nurses from five hospitals through individual, face-to-face interviews, and nine link nurses from four hospitals through four online focus groups (table IIa and IIb).

Link nurses volunteered for the role based on their interest in infection prevention or became a link nurse as a part of their position as a senior nurse. In general, link nurses confirmed being interested in the topic and were keen on increasing their knowledge on infection prevention, for themselves and for their colleagues. This interest was based on their motivation to provide safe care or was driven by more personal reasons (e.g. being found to be a carrier of methicillin-resistant *Staphylococcus aureus* during a contact tracing procedure).

Table IIa. Characteristics of link nurses in face-to-face interviews

	Infection Control Link Nurses (n=17) **n (%)**
Gender	
Female	16 (94)
Setting	
University hospital	13 (76)
General hospital	4 (24)
Department	
Inpatient wards	12 (70)
Outpatient clinics	4 (24)
Diagnostic department	1 (6)
Number of years of experience as a nurse	
6-10	3 (18)
>10	13 (76)
Missing	1 (6)
Number of years of experience as a link nurse	
0-5	10 (59)
6-10	5 (29)
Missing	2 (12)
Position	
Senior nurse	8 (47)

The analysis of the interviews led to three main themes: focus on infection prevention activities in the own ward, improvement by small increments and need for inspiration and support.

Table IIb. Characteristics of link nurses in focus group interviews

	Infection Control Link Nurses (n=9) n (%)
Gender	
Female	7 (78)
Setting	
University hospital	8 (89)
General hospital	1 (11)
Department	
Inpatient wards	5 (56)
Outpatient clinics	3 (33)
Diagnostic department	1 (11)

Focus on infection prevention activities in the own ward

ICLN described their role as to identify, monitor, facilitate and inform on infection prevention topics related to their ward.

ICLN described observing their colleagues during the provision of care. When non-adherence was noted, some link nurses discussed their observations in one-on-one conversations with their peers. Others discussed their observations in a more general way, during team meetings or described their observations and provided suggestions for improvement in emails or newsletters. In addition to these observations in daily practice, some ICLN performed audits and discussed the results with their colleagues.

> I have conversations with my colleagues about the way they provide their care. It gives me an understanding of their knowledge and provided an opportunity to answer questions. I often notice a lack of knowledge. With these conversations I can inform them. [interview 5, university hospital, inpatient ward]

When infection prevention questions on specific patients arose, ICLN acted as an intermediate between their direct colleagues and the infection prevention team. ICLN narrated that they were able to either immediately answer the question, were rapidly able to find the appropriate protocol, or contacted the infection control helpdesk to help their peers to quickly find the answer.

ICLN translated infection control policies into explicit work instructions or provided practical solutions to support the applicability of these protocols in situations specific to their ward. Translation of these protocols was done at the initiative of the ICLN or as a response to questions raised by team members. When alleged inconsistencies or infeasibilities in the protocols were found, ICLN did not hesitate to consult the infection control practitioner.

> Sometimes, I find infection prevention difficult too, and sometimes I have my doubts. Do we have to disinfect our hands or not? In these situations, I will perform the procedure myself, think it through for a moment, and then report my findings to my peers. [interview 7, university hospital, inpatient ward]

> I wrote a cleaning plan for the department. There are quite a few protocols on cleaning and they are long. I extracted the information that is important for my department and to turned it into a plan specific for our department. [interview 2, university hospital, outpatient clinic]

> My colleagues found it difficult to assess if they had donned their personal protective equipment in the right way. I arranged a large mirror. [focus group 2, university hospital, inpatient ward]

Improvement by small increments

ICLN stressed that improvement was only possible with small increments and found that when they brought their information in a fun way it was more likely to stick.

> At first my colleagues were reluctant. “Oh no, here we go again, we have to adjust our approach…again”. And now, they start to understand the point of these adjustments. [interview 12, general hospital, inpatient ward]

Some ICLN described the link nurse role as challenging; they did not know where to start, what issues to address or how to outline their activities. These link nurses stated the need for more guidance.

> At first, I thought I had to gain knowledge and I would subsequently start to promote infection prevention. Then, I decided to just start some activities. Two weeks ago I promoted the 5 moments of hand hygiene; practice has not changed. I don’t know what to do next. [interview 1, university hospital, outpatient clinic]

Some ICLN reported dealing with resistance of colleagues in the compliance with infection prevention policies. Humor was mentioned as an icebreaker. Self-confidence of ICLN emerged from positive experiences with implementing infection prevention policies, speaking up and addressing colleagues to non-compliance with infection prevention guidelines. It facilitated a pro-active attitude. Self-confidence was perceived as a prerequisite for leading by example and sustained motivation for the role. ICLN were proud of their success in improving safe care and mentioned the incorporation of their link nurse activities into their everyday practice.

> Initially, I did not dare to speak up. However, as an ICLN I felt supported by the organization. I became more certain of myself. I started to think differently "I do not speak up for myself, I speak up for the safety of our patients". Most colleagues had no idea that they did not provide safe care. And well, that of course motivates to speak-up the next time it seems necessary. [interview 5, university hospital, inpatient ward]

Only a few ICLN mentioned that they led by example and that being a role model was an important part of their role.

> I see myself as a role model. I know the protocols and I'm also aware of our weaknesses, especially when the workload is high. I am not perfect either. I share and discuss my own flaws with my colleagues and my intentions to do better next time.[interview 5, university hospital, inpatient ward]

Need for inspiration and support

ICLN described the need for inspiration and support from their peers, the ward management, the infection control practitioner and other link nurses.

Inspiration

Educational sessions were mentioned as a source of inspiration to assume the link nurse role. Infection control practitioners provided tools to help ICLN to transfer their knowledge to their peers. Especially discussing their experiences and sharing success stories during these sessions inspired ICLN to apply these strategies in their own ward. Beside educational sessions, ICLN relied on professional literature, protocols and collaborations with the infection control practitioner as sources of knowledge.

> The infection control practitioner provides a range of tools to get you started. [interview 10, university hospital, outpatient clinic]

Sparring partners

Link nurses stressed the importance of a buddy on the ward to discuss how to execute plans and initiatives. Most link nurses choose a peer as their sparring partner, some wards formally appointed a second ICLN for this purpose.

> I have a link nurse buddy. There are many colleagues in my team with a variety of competences that are willing to help. So if I need a sounding board, I can always have a discussion with my buddy or with one of my other colleagues. [interview 2, university hospital, outpatient clinic]

Support from the infection control practitioner

A proactive role was expected from the infection control practitioner and link nurses expressed the availability and accessibility of an infection control practitioner as a precondition to fulfil their role. Infection control practitioners acted as a hotline, a source of information for ad hoc questions and as a coach during more complex questions. Support from the infection control practitioner helped ICLN to operationalize protocols and translate them into workable instructions for their specific department or workflow. ICLN expressed the urge to team up as equal partners. When this support was not readily available, ICLN felt hindered in the execution of their role and questioned the importance of their initiatives.

> I'm in close contact with the infection control practitioner. I told her that we needed to organize some education on COVID-19 and the accompanying infection prevention measures. Colleagues did not understand the need of social distancing during coffee breaks, because at the bedside nurses work so closely together. [focus group 1, university hospital, inpatient ward]

Support from the ward manager

Link nurses expected their ward manager to acknowledge and validate the link nurse role to the rest of the team, e.g. when peers resist to comply with infection control policies. Link nurses felt their role was undermined when this support was not in place.

> I know exactly which colleagues do and do not comply. And when I observe non-compliance, I discuss my observations with them. If these conversations have no effect, I can turn to my supervisor. She has much more authority than I do. [interview 8, university hospital, inpatient ward]

Collaboration with other link nurses

Most link nurses expressed the need to collaborate with link nurses throughout the hospital, though they did not take any initiative to organize such collaboration.

> I would like to see the other ICLN more often; to exchange information and strategies. To learn from each other and to collaborate. [interview 13, general hospital, inpatient ward]

ICLN in times of the COVID-19 pandemic

During the recent COVID-19 pandemic ICLN felt their link nurse responsibilities were magnified. Although overwhelmed by the situation and the rapidly changing policies, ICLN felt responsible to read the daily updated COVID-19 protocols and to provide their peers with concise and up-to-date information. ICLN felt their knowledge on infection control contributed to their understanding of the measures and hence their ability to answer questions from their peers.

> As a link nurse I had more knowledge on this topic. My colleagues turned to me for answers. There were a lot of questions and a lot of uncertainties. I read the updates on the protocol, sometimes two or three times a day. They expected me to be up-to-date, but also understood that I did not have all the answers either. [focus group 1, university hospital, inpatient ward]

Some ICLN were transferred to another other ward for a short period of time during the first wave of the COVID-19 pandemic. They described that the focus on their link nurse role diminished.

> During the first COVD wave I was transferred to the intensive care unit. I thought about the measures and whether they made sense to me, but I kept a low profile… Me too, I was overwhelmed. The infection control department was in control of the donning and doffing policies. I came to support the intensive care nurses; the link nurse role was never discussed at all. It never came to my mind either. [focus group 2, university hospitals, inpatient wards]

DISCUSSION

In this qualitative multi-center study, we explored the experiences with and perceptions of ICLN on their role in acute care hospitals. ICLN mainly focus on infection prevention activities in their own ward and seem to restrict their focus on one or two infection prevention topics (e.g. hand hygiene, isolation precautions, cleaning and disinfection policies). ICLN improve practice by small increments as they operationalize infection prevention policies into workable instructions, share their knowledge with peers by answering their questions and observe them during care procedures. The experiences of ICLN with their role vary from feeling challenged to get started to confident initiatives that smoothly lead to ward-based improvements. The perception of ICLN is influenced by positive experiences with their link nurse activities. ICLN are inspired to initiate activities by sharing best practices with other ICLN, bolstered by a proactive infection control practitioner and support of the ward manager.

Our findings on ICLN' needs for support from various stakeholders builds on the work of Williams and colleagues, who found that ICLN should have access to formal and informal support mechanisms[7]. The appropriate operationalization of this support is needed to facilitate ICLN to undertake the role[7, 11]. Therefore, the roles and responsibilities of the ICLN, the team manager, buddies and the infection control practitioner must be defined and balanced at the ward level, with respect to the local culture and power dynamics. If these stakeholders can join forces, conditions are created for effective implementation of safe practices with interventions that are adjusted to local priorities, ward culture, and its context specific facilitators and barriers[12-15]. The ward manager has formal authority and is therefore pre-eminently able to affirm the importance of infection prevention and the link nurse role, to provide back-up and strengthen the influence of the ICLN[16, 17]. Collaboration with peers can help ICLN to overcome resistance and engage team members in improving practice[16]. The infection control practitioner can facilitate this micro network by providing and translating knowledge on infection prevention. When infection control practitioners also focus on the development of positive relationships with these local micro networks, this facilitates interaction, mutual understanding and therefore enhances adoption of knowledge[18]. In addition, infection control practitioners can align ICLN from departments that work on similar projects. This way infection control practitioners can provide reliable information and control the application of this information during the planning of these projects[19]. This so-called brokerage is known to provide an efficient way of using resources and enhances the ability for ICLN to learn and to collaborate[18].

The need of interviewees to collaborate with ICLN from other wards is consistent with findings from a study of Hasson *et al.* in which palliative care link nurses stipulated the need of reinforcement from their link nurse partners[20]. Current

ICLN programs mainly focus on the transfer of knowledge and skills[3]. However, education as a self-contained intervention is known to sort little effect[21, 22]. This explains why ICLN are only loosely connected and do not take the initiative to organize collaborations[23, 24]. It could also explain why the link nurse role seems to be bound by the link nurse's work environment. At the hospital level, this could mean that future ICLN programs should facilitate ICLN to connect within a network that facilitates information sharing, fosters relationships and promotes interdepartmental collaborations. Networks with these features are considered to positively impact implementation and are associated with sustainability and the creative solving of problems[25, 26].

The ability of ICLN to adopt infection prevention protocols, monitor their compliance and adjust them to fit the unpredictable and complex clinical conditions of their specific wards, aligns with the concepts of the Safety II perspective on healthcare. Safety II facilitates a positive approach with the health care worker at the center that accepts variation, embraces variability in protocols and encourages flexible ways of working[27, 28]. It can be used to understand the complex processes of the daily practices and sees humans as a part of the solution. The rationale behind it is that protocols and procedures can never anticipate all situations that can occur[29]. ICLN that successfully contribute to this flexible way of applying infection prevention and enable their peers to mindfully adapt their care can be defined as resilient or empowered health care workers[30, 31]. These context-specific process improvements contribute to patient safety but may not show in measurements on guideline adherence. An in-depth description could help understand how ICLN' workarounds, adaptions and adjustments to protocols contribute to safe practice. It might reveal possibilities to further reduce the gap between infection prevention policies (work-as-imagined) and their application in the variety of local contexts within the hospital environment (work-as-done)[32].

Our study findings should be interpreted in light of some limitations. The project leader of the link nurse program in our hospital is also the main researcher, which might have introduced social desirability bias. However, the link nurses from the hospital of the project leader were interviewed by an independent researcher (BS). Also, we did not see differences in the answers from the interviews with link nurse from other hospitals. Second, as link nurses volunteered to participate in the interviews, this increased the risk of including only highly motivated respondents. The responders in our interviews, however, mentioned both positive and negative experiences with the link nurse role and program; this makes such a bias less likely. A third limitation is that we performed the focus group interviews through an online platform and experienced some technical difficulties . We did not experience restrictions in interpersonal exchanges and encouraged interaction, nevertheless it could have limited the interaction between participants .

A strength of his study is the multisite design, resulting in a diverse sample of link nurses in different working environments (e.g. hospital and ward) and the variety in years of experience as a nurse and as an ICLN. It provided the possibility to explore the experiences of ICLN in various settings. The qualitative design added to the depth of the information and provided descriptions of their implementation efforts in everyday practice.

In conclusion, this analysis of experiences and perceptions of ICLN points to the importance of inspiration and support to help ICLN in assuming their role. With these preconditions in place, ICLN are more likely to feel empowered and consequently more likely to take impactful initiatives that contribute to the uptake of safe practices at the ward level. Therefore, activities to improve resilience and the empowerment of ICLN should be one of the pillars of ICLN programs.

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CHAPTER 5

Effectiveness of an infection control link nurse program on healthcare worker compliance with the hospital dress code: a single center longitudinal study

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Effectiveness of a behavioral approach to improve health care workers' compliance with hospital dress code
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ABSTRACT

Background

The VU University Medical Center, a tertiary care hospital in the Netherlands, has adopted a dress code based on national guidelines. It includes uniforms provided by the hospital and a 'bare-below-the-elbow' policy for all health care workers (HCW) in direct patient care. Since compliance was poor, we sought to improve adherence by interventions targeted at the main causes of non-compliance.

Objective

To measure compliance with the dress code, to assess causes of non-compliance and to assess whether a behavioral approach (combing a nominal group technique with participatory action) is effective in improving compliance.

Methods

Between March 2014 and June 2016, 1920 HCW were observed in hospital hallways for adherence to the policy, at baseline and at follow-up measurements. Based on the outcome of the baseline measurement, a nominal group technique was applied to assess causes of non-compliance. The found causes served as input for interventions, that were developed, prioritized and tailored to specific groups of HCW and specific departments by participatory action.

Results

We identified lack of knowledge, lack of facilities, and negative attitudes as main causes for non-compliance. The importance of each cause varied for different groups of HCW. Tailored interventions targeted at these causes increased overall compliance with 39.6% (95%CI 31.7-47.5).

Conclusion

The combination of a nominal group technique and participatory action approach is an effective method to increase and sustain compliance with hospital dress code. This combined approach may also be useful to improve adherence to other guidelines.

BACKGROUND

To prevent transmission of pathogens and health care associated infections, proper infection control is paramount. Hand hygiene in particular has proven very important in the prevention of healthcare-associated infections,[1] but adherence is low.[2,3] In addition, proper hand hygiene is hindered by rings, wristwatches and long sleeves.[4,5] Through jewelry, [6,7] artificial nails[8] and clothing[9,10,11] health care workers (HCW) can transfer microorganisms to patients, colleagues or themselves. Therefore, a hospital dress code has been defined for HCW in direct patient care at the VU University Medical Center, a 713-bed tertiary care hospital in the Netherlands. The dress code entails proper wearing of hospital uniforms and a 'bare-below-the-elbow' policy. Although the hospital has set these standards and provides clean uniforms and scrubs every day, compliance with the dress code was poor.

In order to structurally improve guideline adherence, behavioral change is required. Group norms tend to guide behavior of group members, and therefore may play an important role in the individual willingness to comply with infection prevention policies.[12,13] To achieve behavioral change, insight is needed into the interaction between individuals, groups and the working environment and its effect on compliance.

The nominal group technique (NGT) is a decision making method. It involves various panel rounds and combines elements from focus groups and the Delphi method. This structured group process can be used to generate ideas, reach consensus and engage group members in possible ways to solve a problem.[14,15] NTG has proven useful in a range of health care settings.[16] Its democratic style, the iterative character and the avoidance of bias caused by interpretation of the researcher has been shown to promote a high volume of high quality responses.[17] Therefore it can help to gain insight in behavioral components and other aspects of non-compliance.

Participatory action research (PAR) is a collective inquiry of researchers and participants aimed at understanding and improving a process.[18] It has proven to be an empowering approach to guideline implementation in health care settings.[19] As a PAR approach focuses on adapting interventions to the existing needs of an implementation situation it might be a suitable approach to enhance compliance.[20] We hypothesized that combining PAR with NGT can create behavioral change and improve compliance with our hospital's dress code. Therefore, we aimed to measure compliance with the dress code, to assess causes of non-compliance, to devise an approach to improve compliance by PAR, and finally to assess whether this approach was effective in improving compliance.

METHODS

Hospital dress code

The hospital dress code is based on guidelines by the Working Group on Infection Prevention (WIP), an independent organization for infection prevention guideline development in the Netherlands.[21] The dress code requires all HCW to 1) wear hospital uniforms or scrubs when in direct patient care, and change these at least once a day, or sooner if they become visibly contaminated; 2) adhere to the 'bare-below-the-elbow' policy (no long sleeves, no hand or wrist jewelry and no watches) and 3) adhere to the guidelines for keeping of hair, beards and nails (full description in Table I).

Table I Hospital dress code based on Dutch national guidelines

Item	Criteria
Uniform	Uniform is complete, visibly clean and worn closed and exchanged for a clean copy every day.
Hair	Long hair is worn up, not touching the shoulder; headscarves are visibly clean and not worn over the shoulder.
Length of sleeves	Uniform sleeves are worn above the elbow, sleeves of personal clothing not visible.
Watch or wrist jewelry	No watches, wrist jewelry, piercings in hand or lower arm.
Rings	No rings.
Beards/moustaches	Worn short and groomed.
Nails	Nails are short and clean, no artificial nails or nail polish.

Measurement of compliance with the dress code

HCW where covertly observed in hospital hallways, by an infection control expert and a research nurse, both trained specifically for these observations. HCW were identified as physicians, nurses or other HCW by their job-specific uniform. Job-specific uniforms are provided by hospital ID card and therefore a reliable means of identification.

Observers noted type of HCW, and scored compliance with every item of the dress code. 'Compliant with the protocol' was defined as adherence to all items. At each measurement, 240 HCW (80 physicians, 80 nurses and 80 other HCW) were scored, totaling 1920 HCW over all 8 time points. Compliance was measured at baseline (T1) and at irregular intervals (T2–T8) thereafter, from March 2014 to June 2016.

Table II Timeline of the project

Time in months	Intervention	Measurement
1		
2		pilot
3		T1
3.5	Stakeholders informed on results of baseline measurement.	
4.5	Link nurses educated on hospital dress code, trained to monitor compliance in their own ward; start of the Nominal Group Technique.	
4.5	Hospital management re-informed employees on the dress code and communicated this extensively.	
5.5	Completion of the nominal group technique.	
6	Extra means allocated, (expansion of range and number of uniforms, increase of number of wardrobes and lockers).	
8		T2
9	Introduction of role models; evaluation of all hospital-related stock photos for correct display according to dress code; poster campaign addressing the responsibility of each health care worker to comply with the policy and give positive feedback to compliant colleagues.	
10	The hospital management initiated a feedback culture and started addressing health care workers who did not comply with the protocol.	
11		T3
13		T4
15	Second poster campaign	
16		T5
20		T6
22	A brochure was released with the dress code and presented in person to the head of each department or ward. Causes of non-compliance again were discussed per ward. Strategies to achieve compliance were tailored by department.	
23	All health care workers with consent of the company for the home laundering of the uniform were personally contacted and instructed with regard to this home laundering.	
26	In a concluding report to hospital management the advice was given to secure obtained results by using periodic measurements as steering information in guidance within the various divisions of the hospital.	
26.5		T7
30		T8

Nominal group technique

In our hospital, a network of link nurses is operational for improvement of infection control practices. These nurses work on clinical wards or outpatient clinics and act as a link between their own unit and the infection control team. After regular

training sessions, link nurses are asked to raise awareness on the discussed topic and implement accompanying policies by motivating their colleagues to improve clinical practice. In one of the training sessions the link nurses were educated in the utility and necessity of the hospital dress code, trained to observe compliance in their own ward and asked to assess causes for non-compliance. To allow the link nurses to fulfill their role we modified the technique and used 2 consecutive digital sessions to generate an overview of main causes of non-compliance. In the first session, link nurses were invited by e-mail to discuss causes of compliance and non-compliance with colleagues on their own ward and to report their findings. In a second session the answers were verified; we checked whether all main causes had been identified by presenting the link nurses with an overview of all input. In this session, link nurses were also asked to discuss and prioritize possible solutions with their colleagues. These findings were presented for discussion at meetings of the Nursing Advisory Council and the Medical Staff Advisory Board. With input of these forums the overview was finalized and consensus was reached on three main causes and the priority of interventions. We combined these outcomes to develop a set of interventions tailored per group of HCW or department. Interventions were implemented in collaboration with the link nurses, hospital management and other relevant stakeholders (PAR). Details of the timeline of the project, and of the final, refined strategy are outlined in Table II.

Statistical analysis

Analyses were performed per type of HCW, per item as well as for overall compliance. Results were expressed as proportion of HCW compliant with hospital dress code**.** Confidence intervals (CI's) were calculated using Wilson's score. The Taylor series were used to calculate CI's for difference scores. An ordinary least squares regression model was fitted to identify the change in compliance over time using a linear spline with a knot at T2 and an interaction term to assess the effects of the implementation strategy and interaction effects between the groups of HCW. All analyses were performed with R (Regression Modeling Strategies (R package version 5.0-0).[22,23]

RESULTS

Baseline compliance (T1)

Compliance results were analyzed per item, overall, and for each group of HCW separately (Table 3 in supplementary material). Nurses showed higher overall compliance than physicians and other HCW. In this first measurement two-thirds of the nurses, less than half of the physicians and just over a quarter of other HCW were compliant with all items of the protocol. Relative to other items, HCW were least compliant with appropriate wearing of their uniform. Nurses were more likely to comply with the uniform item than physicians or other HCW. Physicians also tended

to wear wristwatches and wear long sleeves and therefore they complied less with the 'bare-below-the-elbow' policy. Most deviations were observed for the other HCW. This group wore long sleeves, rings and wristwatches. Many members of this group wore incomplete uniforms (e.g. only the jacket instead of the complete uniform).

Main causes of non-compliance

Causes of non-compliance were divided into three main areas: lack of knowledge, lack of facilities and negative attitudes.

Lack of knowledge

Nurses described their uniform routines as habitual behavior. Several wards had detailed their own policy and created their own routine unconscious of their deviation from the hospital policy. Colleagues with administrative positions in the outpatient clinic mentioned that they wore a jacket to be recognizable as a hospital employee. Furthermore, nurses and physicians found the description of some protocol items unclear. Some items were open to interpretation, which led to confusion and discussion. Clarifying the purpose of the policy as an infection prevention measure and a clear protocol were identified as possible facilitators for improving compliance.

Lack of facilities

HCW reported the limited range of uniforms and poor fit as reasons for not wearing their uniform. Especially nurses described the need of a warm jacket during nightshifts. Physicians reported the queue at the distribution point and its location as causing too much delay in obtaining a clean coat and therefore a 'loss of time'. The lack of availability of distribution points, uniforms, lockers and dressing rooms appeared a key barrier to compliance; providing extra facilities was identified as a necessity for improving compliance.

Negative attitudes

Physicians mentioned the lack of evidence that a dress code contributes to the prevention of health care associated infections as motivation to deviate from the protocol. Nurses mentioned the influence of negative role models. To address these negative role models i.e. heads of medical departments, experienced physicians and nurses was felt as difficult because of the seniority and status of these role models. Nurses did not address these role models to avoid conflicts and confrontation. Promotion of a feedback culture, supported by hospital management, and improving awareness among these role models of their negative influence on compliance by other HCW were recommended to improve compliance.

Follow-up measurements (T2 –T8)

Figure I displays the results on overall compliance and compliance per group over the full time period of observations (T1-T8). After the first set of interventions aimed at improving knowledge and facilitating employees, the overall compliance with the dress code improved significantly, from 42.5% to 65.4% (β=0.04, p=0.001) over a five-month period. To sustain this improvement, interventions aimed at maintaining focus on the dress code and addressing non-compliant employees were implemented. Thereafter (T3 to T7), an additional significant increase in overall compliance from 65.4% to 82.1% (β=0.0008, p=0.01) was achieved. Compliance of physicians increased with 38.7% (95%CI 24.7–52.8) over the whole study period. For nurses and other HCW this increase was 27.5% (95%CI 14.6–40.5) and 52.5% (95%CI 39.4–65.6) respectively.

The increase in compliance was sustained throughout the study period for physicians and nurses but not for other HCW. Between T3 and T7 we focused on strategies to achieve full compliance within this group, which eventually increased compliance to the level of physicians and nurses. Introducing an interaction term for the effect of the intervention strategy in the different groups yielded a non-significant effect (p=0.06), which indicates the intervention strategy had similar efficacy on all groups.

At the end of the project compliance had improved significantly for all of the particular items of the protocol (Supplementary material). All groups were more compliant with appropriate wearing of their uniform. Physicians also wore wristwatches and long sleeves less often. Other HCW improved compliance and wore less long sleeves, rings, wristwatches and less incomplete uniforms.

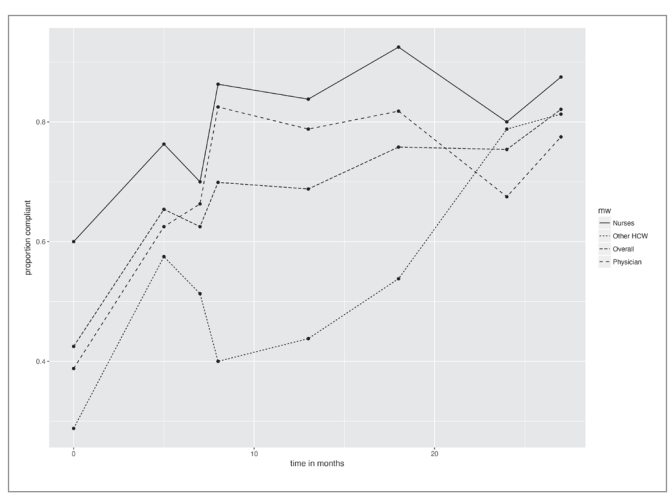

Figure I Proportion of Health Care Workers compliant with dress code

DISCUSSION

In this study, hospital wide compliance with a hospital dress code improved significantly following a tailored intervention strategy. Interventions were based on main causes for non-compliance, assessed with a nominal group technique with stakeholders and a participatory action approach and resulted in an almost 40% absolute increase in compliance. Regular compliance measurements with feedback helped in maintaining improvement and focus on this hospital standard.

These results strengthen previous findings, that to improve compliance, exploration of barriers and facilitators is essential.[15] Compliance with guideline implementation is considered to be complex. Therefore, assessing main causes for non-compliance through NGT was the first step in our project instead of the final product. Guideline implementation requires interventions that specifically target identified barriers and take into consideration the department, profession and setting.[19] PAR has been shown to be effective in different groups of HCW in various fields of healthcare.[24-26] Experiences in infection control show that a PAR approach is a potential useful method to improve hospital wide guideline adherence.[27] It is a collaborative process where working with people in an educative and empowering manner is essential.[20] The infection prevention team initiated the improvement of compliance by discussion regarding causes underlying non-compliance, by exploration of possible solutions, and by solving the problem through management support and involvement of all stakeholders. PAR is a cyclical process of research, action and reflection[28] and in contrast to conventional research, we deliberately intervened during the research process.[29] PAR is an ongoing process rather than a short-term intervention[31] and the flexibility of this method offered the possibility to adjust interventions during the project and to take the results from follow-up measurements into account. Physicians and nurses immediately showed a sustained increase in compliance over time after the first set of interventions was applied in our hospital. In the group of other HCW, the first interventions were not specifically tailored to their department. Halfway through the project we started including these HCW in the interventions, after which their compliance rose to rates comparable to that of nurses and physicians. These findings emphasize the importance of actively involving HCW in the process and to tailor interventions to specific groups.[19] A punitive approach generally does not lead to a sustainable behavioral change[31] and was therefore avoided.

As highlighted, items for which (non-)compliance was highest differed between the different groups of HCW. At the end of the project these differences remained, but compliance itself had improved. Much of this collective behavior is based on the behavior of role models. Observing others (non)complying with a specific norm can influence HCW behavior.[32-34] To see a role model comply and wear the uniform as appropriate evokes the so-called cross norm inhibition effect. It will

strengthen the perception of the norm and encourage to comply. Nurses in our study described the presence of negative role models as an important cause of non-compliance. Further study could specifically address this aspect.

Our study has some limitations. We performed only one standardized baseline measurement. The initial steep increase in compliance could have been incorporated before the implementation of the first set of interventions. However, audits in the previous year showed compliance rates similar to those measured at baseline, which makes a rise in compliance as a result of the interventions plausible. Furthermore, we did not measure whether HCW comply with the daily changing of the uniforms for laundering as data on this part of the protocol were unavailable.

Overall, the democratic, pragmatic approach and its flexibility turns NGT combined with PAR into an empowering method that is easy to apply. This behavioral approach appears to be a viable way to improve hospital wide infection control practices. As the results of this, NGT and the following tailored interventions are a product of our particular process, they are specifically applicable in our setting. Therefore, we suggest that the method should be applied in other health care settings to develop interventions enhancing compliance with protocols and guidelines tailored to the local situation.

SUPPLEMENTARY MATERIAL

Baseline and final compliance overall, per item and per group of health care workers

	Baseline compliance (T1)	Final compliance (T8)	∆ T1-T8
	proportion compliant (% compliance) [95% CI] *	proportion compliant (% compliance) [95% CI] *	difference score in % [95% CI] **
Overall			
compliant with protocol	102/240 (42.5) [36.4 – 48.8]	197/240 (82.1) [76.7 – 86.4]	39.6 [31.7 – 47.5]
no rings	211/240 (87.9) [83.2 – 91.5]	237/240 (98.8) [96.4 – 99.6]	10.8 [6.5 – 15.2]
no wristwatches	200/240 (83.3) [78.1 – 87.5]	233/240 (97.1) [94.1 – 98.5]	13.8 [8.6 – 18.9]
no long sleeves	191/240 (79.6) [74.0 – 84.2]	227/240 (94.6) [91.0 – 96.8]	15.0 [9.2 – 20.9]
uniform	167/240 (69.6) [63.5 – 75.1]	226 /240 (94.2) [90.4 – 96.5]	24.6 [18.1 – 31.1]
no long nails	234/240 (97.5) [94.7 – 98.8]	240/240 (100) [98.4 – 100]	2.5 [0.5 – 4.5]
long hair up	217/240 (90.4) [86.0 – 93.5]	231/240 (96.3) [93.0 – 98.0]	5.8 [1.4 – 10.3]
no long beard	240/240 (100) [98.4 – 100]	240/240 (100) [98.4 – 100]	-
Physicians			
compliant with protocol	31/80 (38.8) [28.8 – 49.7]	62/80 (77.5) [67.2 – 85.3]	38.8 [24.7 – 52.8]
no rings	74/80 (92.5) [84.6 – 96.5]	79/80 (98.8) [93.3 – 99.8]	6.3 [-0.01 – 12.5]
no wristwatches	66/ 80 (82.5) [72.7 – 89.3]	78/80 (97.5) [91.3 – 99.3]	15.0 [6.0 – 24.0]
no long sleeves	49/80 (61.3) [50.3 – 71.2]	72/80 (90) [81.5 – 94.8]	28.8 [16.2 – 41.3]
uniform	62/80 (77.5) [67.2 – 85.3]	74/80 (92.5) [84.6 – 95.5]	15.0 [4.2 – 25.8]
no long nails	80/80 (100) [95.4 – 100]	80/80 (100) [95.4 – 100]	-
long hair up	73/80 (91.3) [83.0 – 95.7]	76/80 (95) [87.8 – 98.0]	3.8 [-4.1 – 11.6]
no long beard	80/80 (100) [95.4 – 100]	80/80 (100) [95.4 – 100]	-

	Baseline compliance (T1)	Final compliance (T8)	∆ T1-T8
	proportion compliant (% compliance) [95% CI] *	proportion compliant (% compliance) [95% CI] *	difference score in % [95% CI] **
Nurses			
compliant with protocol	48/80 (60.00) [49.0 – 70.0]	70/80 (87.5) [78.5 – 93.1]	27.5 [14.6 – 40.5]
no rings	71/80 (88.8) [80.0 – 94.0]	80/80 (100) [95.4 – 100]	11.3 [4.3 – 18.2]
no wristwatches	71/80 (88.8) [80.0 – 94.0]	79/80 (98.8) [93.3 – 99.8]	10.0 [2.7 – 17.3]
no long sleeves	78/80 (97.5) [91.3 – 99.3]	80/80 (100) [95.4 – 100]	2.5 [-0.9 – 5.9]
uniform	66/80 (82.5) [72.7 – 89.3]	75/80 (93.8) [86.2 – 97.3]	11.3 [1.4 – 21.1]
no long nails	78/80 (97.5) [91.3 – 99.3]	80/80 (100) [95.4 – 100]	2.5 [-0.9 – 5.9]
long hair up	72/80 (90) [81.5 – 94.8]	76/80 (95) [87.8 – 98.0]	5.0 [-3.1 – 13.1]
no long beard	80/80 (100) [95.4 – 100]	80/80 (100) [95.4 – 100]	-
Other HCW***			
compliant with protocol	23/80 (28.8) [20.0 – 39.5]	65/80 (81.3) [71.3 – 88.3]	52.5 [39.4 – 65.6]
no rings	66/80 (82.5) [72.7 – 89.3]	78/80 (97.5) [91.3 – 99.3]	15 [6.0 – 24.0]
no wristwatches	63/80 (78.8) [68.6 – 86.3]	76/80 (95) [87.8 – 98.0]	16.3 [6.1 – 26.4]
no long sleeves	64/80 (80) [70.0 – 87.3]	75/80 (93.8) [86.2 – 97.3]	13.8 [3.5 – 24.0]
uniform	39/80(48.8) [38.1 – 59.5]	77/80 (96.3) [89.5 – 98.7]	47.5 [35.8 – 59.2]
no long nails	76/80 (95) [87.8 – 98.0]	80/80 (100) [95.4 – 100]	5.0 [0.2 – 9.8]
long hair up	72/80 (90) [81.5 – 94.8]	79/80 (98.8) [93.3 – 99.8]	8.8 [1.7 – 15.8]
no long beard	80/80 (100) [95.4 – 100]	80/80 (100) [95.4 – 100]	-

* *95% confidence intervals were calculated using Wilsons' score,* ** *95% confidence intervals were calculated using Taylor series,* *** *health care workers*

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CHAPTER 6

Application of the RE-AIM framework to evaluate an infection control link nurse program; a single center study

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Submitted

ABSTRACT

Background

Important elements of programs that train and support infection control link nurses (ICLN) are the engagement of stakeholders, support from hospital and ward management and a structure for iterative improvement. The effects of programs, that combine all these elements, are unknown. We evaluated such a comprehensive program to explore its impact on link nurses and infection prevention practices and routines.

Methods

We used the RE-AIM framework to evaluate our ICLN training and support program. We organized the outcomes along its five dimensions: Reach, Effectiveness, Adoption, Implementation and Maintenance.

Results

Between 2014 and 2018, on average 91% of the inpatient wards and 58% of the outpatient clinics participated in the program (Reach) and impacted guideline adherence in inpatient wards. Link nurses felt engaged and empowered, and perceived their contribution to these results as pivotal. Ward managers confirmed the value of ICLN to help with implementing IPC practices (Effectiveness). The program was adopted both at the hospital and at the ward level (Adoption). Based on ongoing evaluations, the program was adapted by refining education, training and support strategies with emphasis on ward specific aspects (Implementation). The ICLN program was described as a key component of the infection prevention policy to sustain its effects (Maintenance).

Conclusions

Our infection control link nurse program helped ICLN to improve infection prevention practices, especially in inpatient wards. The key to these improvements lay within the adaptability of our link nurse program. It allowed us to tailor program activities to align them with the needs specific to each ward.

BACKGROUND

Infection control link nurses (ICLN) serve as role models in providing safe care; they are trained to monitor infection prevention-related issues on their ward and to inform and facilitate their peers so they can improve their clinical practice[1, 2]. Activities of link nurses are supported by dedicated programs that seek to improve the dissemination and implementation of infection prevention and control guidelines[3, 4]. Key element of these programs is the education of ICLN by infection control practitioners.

Link nurse programs are often developed locally, which means there is a wide variety in content and in ways these programs are developed, implemented, and evaluated. Although their success depends on contextual factors and their specific use, proven effective elements to start and maintain link nurse programs are the engagement of stakeholders, support from hospital and ward management, and a structure for iterative improvement (e.g. plan-do-check-act (PDCA) cycle)[3-8]. In addition, programs that provide training in implementation skills on top of education on infection prevention topics are rated higher by infection control practitioners[7, 9]. At the individual level, as authority is perceived to be essential to fulfill the ICLN role, participation of more experienced nurses is preferred[1, 10, 11]. However, there is limited knowledge on whether ICLN programs that combine these elements are indeed more successful.

To improve the understanding of factors for success and the reporting of outcomes of ICLN programs, evaluation theories, models or frameworks can be used[12]. RE-AIM is a robust, evidence-based framework that facilitates the description of all relevant aspects of programs in real-world settings, providing valuable information on their impact, including barriers and facilitators[13, 14]. It comprises five dimensions: Reach, Effectiveness, Adoption, Implementation and Maintenance[15]. RE-AIM has proven to be applicable in the evaluation of prevention programs; it can help to understand the efficacy and effectiveness of these programs implemented in real-world settings[16-18].

The objective of the present study was to evaluate an ICLN program that was initiated in 2014 by the infection prevention and control department of our university hospital, on all dimensions of the RE-AIM framework. We aimed to 1) explore how it impacted link nurses, infection prevention and control (IPC) practices and routines specific to our university hospital, and 2) contribute to the body of knowledge on how to initiate and sustain an ICLN program using essential elements from literature.

METHODS

Study design

This evaluation assessed our infection control link nurse program and explored its impact on link nurses, infection prevention practices and the routines in our academic hospital. We used routinely collected data, originating from initial planning and start, followed by monitoring of the program from January 2014 to December 2018.

We followed the Standards for Reporting Implementation Studies (StaRI) and the Revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) to report the findings of this study[19, 20].

Ethical considerations

The need for approval for this study was waived by the Medical Ethical Committee at Amsterdam UMC, Vrije Universiteit Amsterdam (2018.485).

Setting

The Amsterdam University Medical Centers, location VUmc is a 700-bed university hospital with inpatient wards and outpatient clinics. The infection prevention and control team is part of the department of Medical Microbiology and Infection Prevention. In 2014, this team initiated an ICLN program as part of a larger project targeting several antimicrobial stewardship and infection control issues. The ICLN program was designed to form closer alliances with nurses from various wards to create awareness of infection prevention and to promote and implement safe practices.

Intervention

The managers of all inpatient wards were requested to recruit at least one link nurse. ICLN from outpatient clinics were welcome to join the program but were only officially recruited and appointed from 2016. Link nurses were educated by infection control practitioners on infection prevention topics, who also registered meeting attendance. After each meeting all ICLN received an email with tools (e.g., PowerPoint, Quick Scan format, newsletter, implementation tip sheet) to implement the infection prevention topics that were discussed during that meeting. When ICLN did not attend, the infection control practitioner sent an email to the link nurse and ward management, offering support for the implementation. In 2018, with the help of ward-based annual plans and evaluations, a PDCA cycle was introduced at the ward level, to address ward specific issues. The ward manager was responsible for the backup and support of the ICLN. The infection control

practitioner provided practical input and coached ICLN in effectuating these plans. Outcomes of the program (e.g., meeting attendance per ward, ward-based plans and audit results) were reported to the board of nursing directors on a yearly basis, the first two years via oral presentations, after 2016 through written reports.

The ICLN program originally consisted of topics that were clustered in one theme per year, based on audit results. Themes were, in order: general precautions, isolation precautions, cleaning and disinfection, and separation of clean and contaminated work areas. To support dissemination, ICLN were trained to perform quick scans on the selected topics and to report their findings to their peers. In 2017 we added training in implementation skills and simulation training to the program. From this time onward, link nurses were also encouraged to share their best practices during festive end-of -year lunch meetings by means of a poster or oral presentation.

Data collection

To evaluate this ICLN program we used the RE-AIM framework. Table I outlines how we defined and measured its five dimensions and which data sources we used.

Table I RE-AIM elements, measurement methods and outcome measures

RE-AIM dimension	Definition operationalized for this study	Assessment Level	Outcome measures	Data Sources
Reach	The absolute number, proportion, and representativeness of inpatient wards and outpatient clinics that appointed an ICLN	Setting	Total number of inpatient wards and outpatient clinics that appointed one or more link nurses	Project documents
			ICLN meeting attendance; proportion and average for inpatient wards and for outpatient clinics	Project documents
			Facilitators and barriers to participate and attend meetings	Interviews

RE-AIM dimension	Definition operationalized for this study	Assessment Level	Outcome measures	Data Sources
Effectiveness	The (perceived) impact of the program	Setting	Change over time in compliance with the hospital dress code	Details published elsewhere (21)
			Change over time in compliance with hand hygiene protocol	Direct observations
			Empowerment of link nurse	Psychological Empowerment Instrument
			Perceived impact of link nurse activities on infection prevention policies (e.g. hand hygiene and dress code)	Interviews
			Perceived mechanisms that contributed to this impact	Interviews
			Perception of ward management regarding the skills of link nurses to disseminate their knowledge and influence routine practice	Ward management survey
Adoption	The willingness of stakeholders to participate in the implementation of the link nurse program	Setting	Stakeholders that were involved in the start of the link nurse project	Project documents
	The willingness of ICLN to initiate link nurse activities	Individual	Work engagement of link nurses	UWES 9 – questionnaire
			Willingness and motivation of link nurses to initiate link nurse activities	Interviews
			Factors that influence willingness and motivation of link nurses	Interviews
Implementation	The fidelity of the ICLN program (was it implemented as intended?)	Setting	Implementation process, preconditions and contextual factors	Project documents
		Individual	Use of the program by link nurses	Interviews

RE-AIM dimension	Definition operationalized for this study	Assessment Level	Outcome measures	Data Sources
Maintenance	Did the ICLN program become part of the hospital or department routine?	Setting	Routines and policies at hospital level that include link nurses	Project documents
		Individual	Link nurse activities that became part of the routine at the ward level	Interviews

Project documentation

During the project we registered the development of the program, information on program outline, stakeholders that were involved, education and training sessions, meeting attendance, and ward-based plans of action.

Direct observations

Since 2014, compliance with the hand hygiene protocol was measured for all inpatient wards once a year. Infection control practitioners and students were trained according to the WHO's Hand Hygiene Technical Reference Manual and Training Films[22]. Observations were performed unannounced and discrete, but not covert[23].

Between March 2014 and June 2016, health care workers were observed for adherence to the hospital dress code in hospital hallways. Observers noted the type of HCW and scored each item of the dress code. 'Compliant with the protocol' was defined as adherence to all items[21].

Questionnaires

Empowerment of ICLN was measured in 2017 and 2018 by the Psychological Empowerment Scale (PES)[24]. This 12-item, 7-point Likert scale survey measures a motivational construct based on four subscales: meaning (the value of the ICLN role in relation to the link nurses' ideals and beliefs), competence (self-efficacy / belief in his or her capability to perform link nurse activities), self-determination (the link nurses' sense of having a choice in initiating and regulating actions) and impact (the degree to which a link nurse can influence the implementation of infection prevention policies in their own ward). Scores reflect how much individual link nurses wish to shape their role and to implement infection prevention policies in their ward, higher scores representing more determination. The validity of the PES has been established before; Cronbach alpha reliability ranged between .85 and .91 for total psychological empowerment[25].

Engagement of ICLN was measured in 2017 and 2018 using the nine-item Utrecht Work Engagement Scale (UWES-9)[26]. This 9-item, 7-point Likert scale survey measures 3 components of work engagement: vigor (feeling strong and resilient in the role of ICLN), dedication (commitment to being a link nurse), and absorption (merging with the role of the link nurse in a positive way). Higher scores represent a higher level of work engagement. The UWES has been validated in several countries, and has reasonable construct validity and high reliability (α =0.93)[26-29]. Link nurses were asked to answer both questionnaires with the ICLN role in mind and to fill in their years of work experience.

In 2017, a survey among ward managers was performed to collect data on their perception of the skills and impact of ICLN. Three questions with a 5 point Likert scale measured if ward managers perceived their link nurses as skilled, proactive in performing their role and impactful. An open text box provided the opportunity for additional comments.

Interviews

Semi-structured face-to-face interviews were performed between April 2 and June 25, 2019 to capture and understand personal views and experiences of ICLN. These interviews were part of a qualitative study with the aim to explore the experiences of infection control link nurses regarding their role, which was published elsewhere[2]. The purpose of this study aligned with current study aims which made secondary data analysis possible.

Data analysis

Quantitative analysis

The number and proportion of wards that appointed one or more ICLN and the number, proportion and average of meeting attendance per ward (Reach) were calculated.

The results of the direct observations were used to calculate change over time for hand hygiene (Effectiveness). The adherence to the hospital dress code was published elsewhere[21].

The ward management survey and background questions were analyzed using descriptive statistics (Effectiveness). Cronbach's alpha was calculated to establish the reliability of the PES and UWES in the study sample. Measures of central tendency (median) and variability (inter quartile range) were used to describe scores for engagement to the link nurse role (Adoption). Spearman's correlations of work experience with engagement and empowerment were calculated. All data

was analyzed using R Studio version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria).

Qualitative analysis

For this study, interviews were reanalyzed with direct content analyses. Pre-determined codes were based on results of other studies on ICLN and on the five dimensions of the RE-AIM framework. Interpretation of text segments and codes were discussed by the research team. The codes that were used can be found in the supplementary material. All data was analyzed in Atlas.Ti software version 8.0 for Windows.

Project documents were systematically searched for information on the implementation process, preconditions and contextual factors, stakeholders that were involved and new routines and policies that include ICLN (Implementation, Maintenance).

Data synthesis

The project documents provided data for all five of the RE-AIM dimensions. First, we summarized findings from these documents per dimension. Next, the outcomes of the interview data were added. Evidence from the remaining data sources was then integrated where applicable.

To explore how the program impacted link nurses and IPC routines, we looked at the domains Effectiveness, Adoption and Implementation, and to explore how the program impacted routines specific to our university hospital we looked at the dimensions Reach and Maintenance.

RESULTS

Reach

At the start of the program, all 25 inpatient wards of our hospital appointed an ICLN. In the following years the number of wards that participated declined to 20 wards. None of the inpatient wards dropped out of the program for longer than one year. The number of outpatient clinics that appointed an ICLN fluctuated per year between eight and fourteen. Some wards struggled with high turnover of staff and with timely replacement of their link nurses. Overall, the average meeting attendance per ICLN per year was 61% for inpatient wards and 34% for outpatient clinics (Table II).

Table II Reach of the ICLN program

	2014	2015	2016	2017	2018	overall
	n(%)	n(%)	n(%)	n(%)	n(%)	%
Inpatient wards that appointed an ICLN	25(100)	24(96)	23(92)	22(88)	20(80)	91.2
Outpatient clinics that appointed an ICLN	10(56)	14(77.8)	9(50)	11(61.1)	8(44.4)	57.8
([‡]n= 4, [§]n=6)	mean(%)[‡]	mean(%)[‡]	mean(%)[‡]	mean(%)[§]	mean(%)[‡]	%
Meeting attendance per inpatient ward	2.7(67.5)	2.7(67.5)	1.9(47.5)	3.8(63.3)	2.4(60)	61.2
Meeting attendance per outpatient clinic	0.9(22.5)	1.2(30)	0.7(17.5)	1.5(37.5)	2.4(60)	33.5

In interviews, ICLN reported feeling facilitated to participate in the program due to their role as a senior staff nurse. Less active ICLN felt their ward managers failed to prioritize infection prevention. Time was also mentioned as a barrier to attend meetings, especially by ICLN from outpatient clinics.

My manager does not encourage me to attend meetings, I don't think infection prevention is on the management agenda right now. [interview 1, outpatient clinics]

Effectiveness

The ICLN program focused on promoting compliance with infection prevention measures, such as the hand hygiene protocol or hospital dress code. Details on the role of the link nurse program in the uptake of the hospital dress code were published elsewhere (21). During meetings the technique of hand hygiene and the identification of the World Health Organization's five moments of hand hygiene were discussed. ICLN learned how to observe compliance and how to collaborate with the ward manager to improve practice. We observed an absolute increase in compliance of 26,5% in four years from 44.5% [95%CI, 42.9-46.0] in 2014 to 70.9% [95%CI, 69.4-72.4] in 2018.

The PES results revealed that link nurses felt moderately to highly empowered (e.g. able to meet the demands of the link nurse role) with a median total score of 5.0 (IQR 4.8-5.4) in 2017 and 5.2 (IQR 4.8-5.4) in 2018 (Table III). Empowerment of the link nurses did not correlate with work experience (r .09, p= .51).

Table III Scores on the psychological empowerment scale (PES)

	2017		2018	
	Median(IQR)	α	**Median(IQR)**	α
Work experience in years	8 (5-22)		15 (5.5-33.8)	
Total PES score	5.0 (4.8-5.4)	.83	5.2 (4.8-5.4)	.94
Meaning	5.7 (5.3-6.0)	.58	5.7 (5.0-6.0)	.92
Competence	5.0 (4.7-5.7)	.70	5.3 (5.0-5.7)	.85
Self-determination	4.7 (4.3-5.0)	.68	5.0 (4.7-5.7)	.86
Impact	4.7 (4.0-5.0)	.70	4.3 (4.2- 5.0)	.92

Response rates were 86.0% (n=37) for 2017 and 44.2% (n=19) for 2018. α = Cronbach's alpha IQR= interquartile ranch

From the interviews it transpired that ICLN perceived their contribution to the improvement in guideline adherence as pivotal. They felt that the knowledge and skills that they had learned and tools that were provided by the program contributed to their link nurse activities. Working side by side with their peers enabled ICLN to observe non-compliance, to provide direct feedback and to provide them with solutions to overcome barriers (e.g. suggest placing extra dispensers).

> You have to keep repeating the observations. At first we missed disinfection of our hands at one specific moment over and over again. We presented the results of our observations to our colleagues and during the staff meeting. We are currently planning our next observations. [interview 8, outpatient clinics]

> I followed a workshop on how to provide constructive feedback … After this workshop I realized I was communicating a bit too direct… So, because I was trained in measuring hand hygiene and in providing feedback to my peers I gained expertise in observing and dealing with non-compliance. [interview 9, outpatient clinics]

Being the only nurse in the team made it more complicated to take action.

> With many different disciplines working in our outpatient clinic there might be different needs, too. I can't oversee all of these needs. [interview 1, outpatient clinics]

Surveyed ward managers underpinned the impact of their link nurses on infection prevention practices and valued them with a median score of 4 (IQR 3-4) out of 5 (Table IV). Ward managers felt that continuing to monitor the impact of their actions was harder for link nurses than to initiate improvements and that the

support of the ward management was pivotal in dealing with resistance and in sustaining the effects.

Table IV Perceived impact of link nurses by ward management

	Median (IQR)
The link nurse at my department has sufficient knowledge about infection prevention measures and sufficient skills to implement them.	4 (4-4)
The link nurse at my department disseminates knowledge on infection prevention.	4(3-4)
The link nurse at my department has sufficient impact on compliance with infection prevention measures.	4(3-4)

Adoption

The board of nursing directors adopted the ICLN program and committed to the recruitment of ICLN through the ward managers. Program principles were highly valued at the organizational level and the program was used as a blueprint for link nurse programs in other disciplines. Partnerships were established with leaders of other programs, such as medication safety, programs for the frail elderly and programs for wound care. The project was awarded the hospital's Profile Prize 2016, which is awarded annually by the board of directors to multi-disciplinary teams that have delivered exceptional multi-year performances in one or more core tasks of the hospital.

In 2017, the link nurses perceived themselves as highly engaged with the link nurse role, with a median work engagement score of 5 (IQR 4.1-5.3). This dedication sustained during 2018; ICLN reported a median score of 5.1 (IQR 4.9-5.6) (Table V). Work engagement of the link nurses did not correlate with work experience (r .17, p= .20).

Table V Scores on the Utrecht Work Engagement Scale (UWES)

	2017		2018	
	Median(IQR)	α	Median(IQR)	α
Work experience in years	8 (5-22)			
Total UWES score	5 (4.1-5.3)	.90	5.1 (4.9-5.6)	.96
Vigor	5 (4.0-5.3)	.75	5 (5.0-5.3)	.91
Dedication	5 (4.3-5.7)	.85	5.4 (5.1-6.0)	.92
Absorption	5(3.7-5.3)	.76	5 (4.4-5.6)	.94

Response rates were 86.0% (n=37) for 2017 and 51.2% (n=22) for 2018. SD = standard deviation IQR= interquartile ranch
α = Cronbach's alpha

Factors that promoted work engagement were the commitment of the hospital and the ward manager to the program and the availability of the infection control practitioner.

> I feel supported by the organization ... I am so proud of our achievements. When I want to implement something, I get carte blanche from my ward manager. The team is also open to improvement. We have developed a positive team spirit ... The infection control practitioners are very accessible, visible within the organization and they keep their promises. That is what keeps my commitment to the ICLN role. [interview 4, clinical ward]

Implementation

At first the program focused on education of ICLN and goals at the hospital level. Meetings were held four times a year. ICLN where educated on predetermined infection prevention topic, trained to perform quick scans and to report their findings to their peers.

The program was adapted to fit the needs of ICLN and was based on ongoing evaluation with ICLN, ward management and the board of nursing directors. Meetings evolved from exchange of knowledge to training of skills during simulation and implementation sessions. We collaborated with specialists in education and training, implementation, project management, personal effectiveness and leadership skills to prepare trainings sessions. During these sessions, time was also dedicated for ICLN to share their best practices.

In addition to hospital-wide infection prevention priorities, goals were formulated per ward together with the ward management, ICLN and the infection control practitioner. This way a bespoke plan of action was created to fit the local context and infection prevention issues of each ward. ICLN felt these plans helped to structure their tasks.

> In my department we work as a team, the ward manager, a physician, an infection control practitioner and two ICLN. We have made an annual plan and discuss the progress of this plan, the barriers that we encounter and divide upcoming tasks during monthly meetings. This way we discuss the infection prevention topics that we feel needs to be addressed in our ward and it provides structure for our actions. [interview 8, inpatient ward]

Maintenance

The ICLN program was described as a key component of the infection prevention policy and the link nurse role was incorporated in the Infection Prevention Plan of the hospital. This plan described the organization and aims of infection control and prevention at the hospital level. Since its effectuation it facilitated and guided activities of the Hospital Infection Prevention Committee in supervising and coordinating infection prevention policies and reporting to the executive board.

ICLN on all inpatient wards were trained by infection control practitioners; the training continuously offered to refresh skills or to train new ICLN. ICLN continued to measure hand hygiene compliance on a regular basis. Additionally, ICLN were taken up in the list of stakeholders in outbreak management, and were assigned a key role in the dissemination of local outbreak information at the ward level.

The role of the link nurse and outcomes of the ward-based plans of action were discussed by ward managers and nursing directors during quarterly meetings. Ward managers were committed to provide the ICLN sufficient time to observe hand hygiene practices.

DISCUSSION

In this study we evaluated an infection control link nurse program that was developed in our academic hospital; this evaluation was performed according to the RE-AIM framework. The results contribute to the understanding of the relation between how an ICLN program is implemented and its sustained effectiveness[3, 30]. Strong reach on the clinical wards and adoption of the program at hospital and individual level was observed; this effect appeared to be the result of endorsement of the program by hospital and ward management and of collaboration with other stakeholders. Implementation was facilitated by providing enough time for adoption of the program. Flexible implementation with adjustments of the program, based on ongoing evaluation led to a shift of focus from hospital goals to goals tailored to the ward level. Our program had low reach and therefore low impact in the outpatient clinics.

Strong adoption of the program by hospital and ward management highlights the well-known importance of support for effective implementation of safe practices. A ward manager that supports and inspires staff to excel and forms partnerships across disciplines is more likely to succeed in the implementation of safe practices [31, 32]. Saint et al. stated that infection control practitioners also have an important leadership role in implementing safe practices; positive interactions with staff, enthusiasm and communicating the end goals of the program are powerful skills[33]. Thus, these behaviors should be kept in mind when leading a link nurse program.

Psychological empowerment of the link nurses and their engagement likely contributed to the adoption and success of our program. Psychological empowerment of nurses is associated with the provision of safe care[34]. Empowerment of nurses correlates positively with work engagement[35, 36]. When nurses feel dedicated to their work, they are more willing to do well. Work engagement is associated with improved patient-quality outcomes and strong interdisciplinary collaborations[34-37]. In line with these findings and related to infection prevention, Gilmartin and colleagues found that greater job satisfaction of nurses correlated with a decreased risk of central line–associated bloodstream infections[37]. Ambiguous results were found regarding the assumption that link nurses should be experienced nurses to have authority, a precondition to have impact. Although being a senior staff nurse was mentioned by ICLN as a facilitator for the uptake of the role, our study could not demonstrate a correlation between work experience and empowerment nor between work experience and engagement. To actively engage and empower ILCN, we introduced a PDCA cycle at the ward level. This provided the opportunity to develop and implement infection prevention activities that were tailored to the local context and to strengthen inter-professional collaboration[32, 38]. It is known that local goals can differ from formal program goals; adaptation to the local context can facilitate success[39]. By co-developing interventions and monitoring implementation, we added to the infrastructure that was required for the implementation of the link nurse role at the ward level. By adding this component, our program progressively evolved to a multi-modal strategy as propagated by the World Health Organization. Interventions that include several elements have proven to be more effective when applied in an integrated way[40].

Our program had relatively low reach in the outpatient clinics. Link nurses from outpatient clinics in our study mentioned, apart from the lack of management support, a lack of resources as a barrier to take action, as observed in other studies[41]. In order to be effective, an infrastructure that allows ICLN to monitor practices and to be a role model in adhering to IPC measures is required. As in outpatient clinics the work of health care workers is more individually organized, it might be harder to be actively involved in supporting colleagues[42]. Due to the multi-professional nature of teams working in the outpatient setting, and due to the setting, relationships between the various professionals are more hierarchical; this may hamper the role of the ICLN too. Romijn et al. found discrepancies in the perceptions of several groups of health care workers on inter-professional collaboration, especially between physicians and other professionals (e.g. nurses). These discrepancies were most apparent with respect to the discussion of new practices and sharing of opinions[43]. In this case situational leadership is needed rather than hierarchical leadership, which underpins the importance of training ICLN in soft skills and especially in leadership skills, as an essential element of ICLN programs[7].

Although case study results have limited generalizability, they yield the unique opportunity to evaluate interventions in their natural context. Key strengths of this evaluation included the use of multiple data sources and of a robust evaluation framework. It provides rich information on strategies to implement and sustain link nurse programs in acute care hospitals.

The main limitation of this study is the absence of formal and systematic data collection. For example, baseline PES and UWES scores were not assessed. We therefore cannot link engagement and empowerment of the link nurses to our program activities. Potentially, link nurses entered the link nurse program because of their work engagement, their interest in infection prevention and their enthusiasm and competences to engage in program activities. The secondary analysis of the interviews was done by only one researcher. This limitation was partially addressed by team discussions with all authors that were also involved in the primary analyses; the data was discussed on multiple occasions. During these sessions reflexivity was encouraged. It reduced the risk of interpretation of the data being guided by team members' knowledge, experiences and expectations (44). Selected quotations from participants are included to allow the reader to judge interpretations and credibility of the analysis.

While we show here that an ICLN program can reach and influence ICLN, and can help to improve safe practices, especially in inpatient wards of acute care hospitals, it is possible that we did not capture all specific pitfalls and benefits of our program. A prospectively designed evaluation of this program in multiple organizations may be needed to showcase the true values of ICLN programs. Patient care shifts from inpatient care to the outpatient environment, leading to more complex care and treatment of more vulnerable patients in outpatient clinics. Increased attention for infection prevention in this part of hospitals is therefore important[42, 45]. Future research should also investigate the possibilities to extend program activities to the outpatient setting.

CONCLUSION

The adaptability of link nurse programs allows the development of program activities that fit the needs of ICLN and allows to tailor program goals and to align these with the goals specific to each ward. Context specific plans of action can be an appropriate and valuable addition to ICLN programs. This implementation approach was found valuable to provide the program with reach, and to make it effective, adoptable, and maintainable.

SUPPLEMENTARY MATERIAL

Pre-determined interview codes

Facilitators and barriers to participate and attend meetings
Perceived impact of link nurse activities on infection prevention policies (e.g. hand hygiene and dress code)
Willingness and motivation of infection control link nurses to initiate link nurse activities
Factors that influence willingness and motivation of infection control link nurses
How infection control link nurses used the program

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CHAPTER 7

Strategies to improve the implementation of infection control link nurse programs in acute care hospitals: a synthesis guided by the Consolidated Framework for Implementation Research

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Strategies to improve the implementation of infection control link nurse programs in acute care hospitals
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ABSTRACT

Background

Infection control practitioners face several challenges when implementing infection control link nurse (ICLN) programs. Identification of strategies to address these can improve the impact of current ICLN programs and guide their future implementation.

Aim

We aimed to identify implementation strategies for ICLN programs in acute care hospitals with the Consolidated Framework for Implementation Research (CFIR)-Expert Recommendations for Implementing Change (ERIC) Implementation Strategy Matching tool.

Methods

An expert panel matched 19 implementation and sustainment barriers, identified in our previous studies, to the most fitting CFIR constructs. Subsequently, we applied the CFIR- ERIC Matching Tool and generated a list of implementation strategies to address these barriers.

Findings

Barriers were predominantly found within the CFIR domains 'inner setting' (characteristics of the implementing organization) and 'process' (stages of implementation). With the ERIC Matching Tool we identified the ten most important strategies to address barriers of implementation of ICLN programs: identify and prepare champions, conduct local consensus discussions, assess for readiness and identify barriers and facilitators, inform local opinion leaders, use facilitation, create a learning collaborative, conduct local needs assessments, develop a formal implementation blueprint, build a coalition, and identify early adopters.

Conclusion

The CFIR domains 'inner setting' and 'process' appeared as most important to impede implementation of ICLN programs in acute care hospitals. Application of the CFIR-ERIC tool highlighted the identification and preparation of champions as the leading strategy for the successful implementation of these programs. With this tool, strategies can be specifically tailored towards local implementation and sustainment barriers.

BACKGROUND

Infection control link nurses (ICLN) play a central role in the dissemination and implementation of infection prevention and control measures. Link nurses can observe infection prevention practices on their ward, and inform and instruct their colleagues[1, 2]. ICLN are supported by programs that are set up and led by infection control practitioners who provide training and support to establish cooperative relations[3-5]. Infection control link nurse programs vary in how they are organized and implemented. This variation relates to all aspects of such programs - i.e. role description, competences that are required to fulfil the link nurse role and activities for and education of ICLN[4, 6].

Previously, we have shown that infection control practitioners face several challenges when implementing policies with the help of link nurse programs[4, 6-8]. Most programs are often set up and led solely by the infection prevention and control team, without further evaluation[4]. The most common challenges that infection prevention link nurses face include operational difficulties in daily practice (e.g. high workload and low staffing) and no clear definitions of their role and responsibilities[1, 6].

To guide infection control practitioners in the execution of their programs and to overcome these challenges, it has previously been suggested to teach implementation and personal leadership skills[1, 4, 7], to perform audit and feedback cycles[4, 5, 7], to provide comprehensive role descriptions[1, 8], and to involve ward and hospital management[1, 8]. These approaches however, have not been grounded in theory. It is therefore not warranted, that these suggestions are the most feasible approach or best possible solution with the most desired effect. Suboptimal implementation of ICLN programs can lead to disappointing effects and will fail to improve practice; the ceasing of ICLN programs because of failure has been reported[1, 4, 8].

Implementation science focusses on how to improve the uptake of research findings and on how to bridge the gap between evidence-based approaches and daily practice[9]. The application of theories, models, or frameworks in intervention design can guide the identification of generalizable approaches and provide a better understanding and explanation of the mechanisms by which implementation succeeds or fails. Implementation science can therefore aid to find evidence-based strategies for successful planning, adopting and sustaining ICLN programs[10].

One of the most cited frameworks in this field, is the Consolidated Framework for Implementation Research (CFIR)[11]. This theoretical framework incorporates constructs associated with effective implementation from 19 implementation

models and theories; it therefore provides a comprehensive overview of the most important theories and conceptual models in implementation research. The CFIR is designed to investigate potential barriers and facilitators, to guide evaluation of an implementation process and can be used to design an implementation plan[11-13]. To design such a plan the CFIR-Expert Recommendations for Implementing Change (ERIC) Implementation Strategy Matching tool can help to select implementation strategies[13]. This tool is based on the CFIR framework and combines constructs from this framework with recommendations for implementation strategies based on expert opinions. It provides an overview of 73 implementation strategies, ranked according to strength or priority for the combination of the barriers that are entered into the tool[12, 13].

Our study provides relevant implementation strategies based on empirical data on barriers to the implementation of ICLN programs. In this paper we aim to provide guidance for better selection of strategies to support the implementation of such programs in acute care hospitals.

METHODS

Design

We used Delphi techniques to identify which CFIR domains and constructs would fit the barriers to implementing and sustaining ICLN programs in acute care hospitals. A Delphi method is an effective method for reaching consensus. It uses at least two rounds of surveys with a panel of experts; each round builds upon the outcomes of the previous one, in an iterative process[14]. In our study, the Delphi rounds were conducted through an online meeting and two email rounds We explicitly chose this technique to include researchers with specific expertise in infection control and researchers with specific expertise relevant to the CFIR constructs. We considered this expertise important for the clarification of barriers and for the matching of these barriers to the best fitting CFIR controls.

We applied the CFIR- ERIC Matching Tool to identify implementation strategies.

Panel members

The Delphi panel comprised four senior researchers and four junior researchers with expertise in microbiology, infection prevention, nursing, implementation science and quality of care. The panellists were recruited purposefully from research groups on quality and safety and on infection prevention in our hospital. One researcher (MD) invited members and organized the meetings, during which she clarified any ambiguities in the description of the barriers and explained the concept of link nurses and ICLN programs.

Data collection and analyses

The consensus meeting and the email rounds were held between April and May 2021. In preparation of the first email round we operationalised the CFIR domains by describing the first domain, the intervention, as containing the key attributes of an ICLN program. This also included the perception of other stakeholders of the value of the program.

The outer setting, the second domain of the framework, was operationalised as the context of the hospital at a meta-level, including the degree to which a hospital is linked to other hospitals in its region, the competition with or peer pressure from these hospitals and other external incentives to implement infection prevention and control guidelines. The inner setting referred to the structure of the hospital, the dynamics of informal networks and lines of communication, characterizing the implementation climate (e.g. is infection prevention a priority in the hospital) and readiness for implementation (e.g. what indicators underpin the decision to implement a link nurse program). The fourth domain described the way the individuals are involved in the development and the implementation of a link nurse program to capture the dynamics between these individuals and the hospital and its influence on the implementation process.

The fifth domain delineated the planning, execution, reflection and evaluation of the intervention: the process of implementation. Since ICLN programs are characterized by constant change, this domain reflected the non-linearity of implementing and maintaining a link nurse program. The different roles of individuals that engage in this process were classified as opinion leaders, formally appointed internal implementation leaders, champions or external change agents.

We also described the barriers to implementing and sustaining a link nurse program in acute care hospitals that we found in literature and our previous studies[2, 4, 6]. Panel members were emailed with an overview of these barriers, inviting them to match these barriers to the most fitting CFIR constructs with the help of the CFIR codebook (https://cfirguide.org/tools/tools-and-templates/). They were also asked to express the rationale for their choices. All panel members returned their answers and comments. With these answers we generated a comprehensive list of possible CFIR constructs and we prepared slides with an overview of these constructs per barrier. In an online meeting, the panel members reflected on these slides and discussed (dis)agreements and possible root causes for barriers. The operationalisation of the CFIR domains helped to guide this discussion. With input from this meeting, we narrowed the list of barriers by compressing and redefining definitions per barrier. These revised descriptions were presented by email and the panel members were asked to consider their previous answers in light of the refined definition and the outcomes of the meeting. If they wished to, they could

change the CFIR construct to match a barrier or make further comments. The experts were also asked to confirm that the description of the barriers and their assessment of the CFIR constructs were the final results.

One researcher (MD) applied the CFIR- ERIC Matching Tool v0.53 (https://cfirguide.org/choosing-strategies/) by entering all identified CFIR constructs into the ERIC tool at once. This tool guides selection of implementation strategies by entering relevant constructs into an Excel form. It then provides a prioritized list of all 73 ERIC implementation strategies, their ranking based on the level of endorsement per barrier reflecting in percentages (higher percentages reflect higher endorsement of the strategy). Strategies are divided in level one strategies (endorsed by ≥50% of the experts) and level two strategies (endorsed by 20% to 49.9% of the experts). The tool also cumulates the percentages of endorsement for all entered barriers. In this way strategies that can address multiple barriers simultaneously are identified. The tool does not operationalize these strategies. We discussed the application and interpretation of the proposed ERIC strategies within the research team (MD, RM, IJ, CVG, MB). We chose to present the 10 strategies with the highest endorsement. This way we included the strategies with the strongest recommendations. We operationalized these strategies by combining the definitions of the CFIR constructs with the definitions of the level one and level two recommended ERIC strategies and specified these narratives with ICLN programs in mind[12, 15]. To identify barrier-specific ERIC strategies we repeated the application of the tool. and entered the CFIR constructs that were matched to each individual barrier. We defined the top five strategies per barrier correspondingly.

RESULTS

CFIR barriers

In our previous studies we identified 19 barriers[2, 4, 6]. In the first email round, all eight panel members mapped individually the most fitting CFIR constructs to these barriers. Only two of the barriers were mapped by all members to the same CFIR construct. All panel members attended the online meeting; it lasted for two hours. During the meeting it became clear that some of the barriers were described too briefly, some of the barriers had the same root cause, and for some barriers more background information was needed. For example, the panel discussed several barriers that link nurses experienced in the uptake of their role at the ward level. These were a lack of support from ward management, insufficient time for link nurse activities and a lack of power that was allotted to the link nurse role. The panel concluded that these three barriers could be summarized as one main barrier with several root causes, namely, the low priority of infection

prevention at the hospital management level. During the meeting, consensus was reached on the CFIR constructs that best fitted each barrier. For one main barrier, consensus was reached on one CFIR construct. The other six main barriers, could be explained by several conditions or underlying root causes. For these barriers, the panel chose the most eligible CFIR constructs, with a maximum of five. This strategy was chosen to generate implementation strategies that would address various root causes and therefore be broadly applicable. With the input from the panel, the 19 barriers were redefined and grouped in seven main barriers (Table I). In the last round, all panel members agreed on the definitions of barriers and accompanying CFIR constructs. The barriers corresponded predominantly with CFIR constructs from the domains inner setting (characteristics of the implementing organization) and process (stages of implementation). None of the barriers corresponded with constructs from the domain outer setting (external influences on the implementation).

Table I Barriers to the implementation of an ICLN program and their matching CFIR constructs

Barrier	Why is this a barrier?	CFIR domain	CFIR construct
Infection control has no priority at the hospital level	There were other priorities at the hospital level (e.g. hospital merger) which resulted in the ceasing of link nurse programs.	Inner setting	Relative Priority Tension for Change
	A lack of time and power (mandate) was allotted to link nurses which resulted in the ceasing of link nurse programs.	Inner setting	Leadership engagement Relative priority
	A lack of support from ward management to acknowledge and validate the link nurse role to the rest of the team e.g. when peers resist to comply with infection control policies. Link nurses felt their role was undermined when this support was not in place.	Inner setting	Leadership engagement
	Operational difficulty at the individual level - high workload and low staffing leaving insufficient time for link nurse activities.	Inner Setting	Available resources

Barrier	Why is this a barrier?	CFIR domain	CFIR construct
The role of link nurses is not defined	At the hospital level a written role profile is essential to clarity, expectations of link nurses for all stakeholders, and to facilitate communication on the role and tasks within the organization. At the individual level a role profile is essential to facilitate link nurses in the uptake and ownership of their role.	Intervention characteristics	Design Quality and Packaging
	The uptake of the link nurse role is experienced as challenging by some link nurses; they do not know where to start, what issues to address or how to shape their activities. For some ICLN, the uptake remains complex even with the help of a written role profile.	Intervention characteristics	Design Quality and Packaging
		Characteristics of individuals	Self-efficacy Individual Stage of Change
ICLN are not accepted by medical staff	The lack of acceptance of the link nurse role by other groups of health care workers may limit the influence of link nurses at their department. A study showed that nurses found it difficult to address some of the medical staff because of their seniority and status and to avoid conflict and confrontation.	Inner setting	Learning climate Culture
		Process	Opinion leaders
		Characteristics of individuals	Knowledge and beliefs about the intervention
ICLN programs are initiated, developed and implemented solely by infection control practitioners	Not all infection control practitioners have a priori knowledge on how to develop complex interventions and guide there implementation. Most ICLN programs are developed while implemented which could result in an incomplete PDSA-cycle.	Intervention characteristics	Design Quality and Packaging
		Process	Planning Executing
		Characteristics of individuals	Self-efficacy Individual Stage of Change

Barrier	Why is this a barrier?	CFIR domain	CFIR construct
Responsibility to educate link nurses lies with infection control practitioners	ICLN programs are initiated and implemented bottom-up, by the infection control team. There is variation in which stakeholders are involved. This could result in a lack of support for the program and impede multidisciplinary collaborations with experts in implementation and education.	Process	Engaging Key stakeholders Formally appointed internal implementation leaders
	Education for ICLN varies widely. Programs that provide education on infection prevention topics and include a training in implementation skills are perceived as more effective programs without education or programs where education included only infection prevention topics.	Intervention characteristics Process	Design Quality and Packaging Key stakeholders
	ICLN programs vary in the way they support their ICLN. Link nurses expressed the availability and accessibility of an infection control practitioner as a precondition to fulfil their role. When this support was not readily available, link nurses felt hindered in the execution of their role and questioned the importance of their initiatives. Therefore a proactive infection control practitioner is a prerequisite for implementation.	Process Characteristics of individuals	Opinion leaders Champions Self-efficacy Individual Stage of Change
Interconnecting link nurses from various departments to exchange experiences and best practices is challenging	Link nurses report the need to collaborate with other link nurses but do not initiate such collaborations.	Inner setting	Compatibility Networks & Communication
Only half of link nurse programs are evaluated	There is no formal evaluation of ICLN programs on structure, process and outcome indicators. Evaluation of efforts focus on the satisfaction of link nurses with the program. Some infection control practitioners reported positive effects based on random observations during ward rounds and gut feeling.	Process	Reflecting & Evaluating

ERIC strategies

The CFIR-ERIC matching tool provided a list of implementation strategies to address all seven barriers to implementation at once. The top 10 strategies to overcome these barriers are listed in order of priority in Table II. The strategy with highest cumulative value of percentages in the ERIC tool, which reflects the highest endorsement by the panel of experts, is to identify and prepare champions. This single strategy will address five constructs with a level one recommendation, eight constructs with a level two recommendation, and can address five of the identified main barriers.

Strategy 1: Identify and prepare champions

Champions are individuals that have informal influence and actively support the link nurse program during implementation. They can help overcome resistance that may hamper the implementation, shift the perception of key stakeholders and influence individuals in an organization who formally or informally influence the attitudes and beliefs of their colleagues with respect to the implementation of the ICLN program. Champions can influence the organizational culture, a critical barrier to leveraging infection prevention knowledge and implementing a ICLN program.

Strategy 2: Conduct local consensus discussions

To reach consensus about the importance of infection prevention and about the appropriateness of an ICLN program the risks of poor infection prevention can be discussed with key stakeholders and local providers (e.g. hospital and ward managers and nurses). These discussions can add to the degree to which stakeholders perceive the need for an ICLN program, to change or implement infection control practices in the hospital, and to the perception of the importance of infection prevention in the organization.

Strategy 3: Assess for readiness and identify barriers and facilitators

A thorough assessment of several aspects of the hospital, such as the availability of resources and staff, of the attitudes of stakeholders and of leadership support and of former successful quality improvements techniques, can help to determine if the hospital is ready for the implementation of an ICLN program, to identify the local barriers that can impede its implementation and the strengths that can leverage or facilitate the link nurse program. It will help to design an implementation plan with actions to promote the effective implementation. It will help to build local capacity to adopt the ICLN program and it can influence the organizational culture.

Table II Top 10 Implementation strategies based on the CFIR - ERIC tool

CFIR constructs	Cumulative value of percentages	Design Quality & Packaging	Networks & Communications	Culture	Tension for Change	Compatibility	Relative Priority	Learning Climate	Leadership Engagement	Available Resources	Knowledge & Beliefs about the Intervention	Self-efficacy	Individual Stage of Change	Planning	Opinion Leaders	Formally appointed internal implementation leaders	Champions	Key Stakeholders	Executing	Reflecting & Evaluating
ERIC Strategies																				
Identify and prepare champions	670	15	17	52	48	21	18	31	41	4	40	30	44	31	64	64	67	63	14	8
Conduct local consensus discussions	439	26	22	22	43	41	46	27	27	0	12	0	20	23	32	14	26	42	7	8
Assess for readiness and identify barriers and facilitators	436	7	13	41	35	34	36	19	14	13	20	11	12	42	14	29	15	38	31	12
Inform local opinion leaders	387	19	22	22	39	3	14	19	18	0	28	4	28	0	57	29	44	29	3	8
Facilitation	363	7	26	30	0	24	14	54	18	4	20	22	8	23	11	21	19	17	24	20
Create a learning collaborative	313	7	35	30	9	14	4	15	5	9	16	30	28	8	11	14	19	33	21	8
Conduct local needs assessment	310	15	9	22	43	21	32	19	14	0	24	0	0	50	14	11	7	21	3	4
Develop a formal implementation blueprint	306	15	13	7	13	3	14	12	23	4	4	11	4	73	0	46	11	8	28	16
Build a coalition	301	0	39	19	9	21	18	19	18	17	16	0	16	4	32	11	30	25	0	8
Identify early adopters	300	11	17	11	13	10	7	12	9	0	20	19	24	12	43	25	41	13	14	0

Level 1 endorsements in dark grey, level 2 endorsements in light grey.
Endorsements in % represent the proportion of panel participants that recommend the strategy for that specific barrier.

Strategy 4: Inform local opinion leaders

When formally appointed with the responsibility to implement an ICLN program, as coordinator, project manager or team leader, an infection control practitioner can inform individuals within the hospital who have formal or informal influence (i.e. opinion leaders) about the ICLN program.

Strategy 5: Facilitation

Infection control practitioners can support link nurses and wards in their effort to adopt and incorporate the link nurse role within their daily practice. This interactive support process typically combines multiple strategies such as enabling and problem solving. It can contribute to a learning climate at the hospital and at the ward level. Within a learning climate the link nurse's input to implement infection prevention practices is validated by the management and by health care workers within the hospital. It will help to accept the ICLN role and for the ICLN to feel valued.

Strategy 6: Create a learning collaborative

Infection control practitioners can facilitate a collaborative learning environment for ICLN to help them to implement infection prevention practices. A link nurse program can include a peer consultation network, an online community of practice or a quality circle. ICLN may meet in person or interact using a wide variety of media. This will facilitate the connections and bonding between the infection control practitioner and the ICLN. It will build a community that contributes to the implementation of infection prevention. At the individual level it will strengthen ICLN's knowledge, skills, enthusiasm, and their belief in their own capability to fulfil the link nurse role within the specific context of their ward.

Strategy 7: Conduct local needs assessments

Before implementing an ICLN program infection control practitioners can assess process and outcome measures related to infection prevention at the hospital level. At the ward level, wards can be approached to identify whether there is a need for a link nurse program and potential considerations for specific elements within the link nurse program. Methods to perform a local needs assessment can include the use of audit data, data mining of administrative records, and qualitative methods such as interviews or focus groups with stakeholders of several wards. The assessment will help to plan and develop a program in advance and add to the quality of the program. It will also add to the tension for change, the degree to which the stakeholders perceive the hospital is in need of an ICLN program, or their ward is in need of an ICLN to change or implement infection control practices.

Strategy 8: Develop a formal implementation blueprint

A formal implementation blueprint is a plan that includes the purpose and scope of the program, a timeframe with milestones and a plan to measure its progress and outcomes. This plan helps the infection control practitioners to guide the ICLN program and its implementation; it should be updated along the way. It will also make clear to the wards what to expect when they adopt the program and appoint a link nurse.

Strategy 9: Build a coalition

Infection control practitioners should invest in relationships and their connections with individual colleagues, wards and services to build a community or team spirit. A strong social network and the quality of formal and informal communications within the hospital may contribute to the effect of an ICLN program. Cultivating these relationships can also help to identify opinion leaders and champions.

Strategy 10: Identify early adopters

Infection control practitioners can learn from the experience of wards and link nurses that adopt the program from the start of implementation. These wards and individual link nurses can help the implementation by sharing their experience with key stakeholders.

Barrier-specific ERIC strategies

Table III provides a summary of the top five ERIC strategies that specifically address each main barrier to the implementation of an ICLN program. The strategies are ranked listed in order of priority. The operationalization of the additional strategies can be found in the supplement.

Table III Barrier specific implementation strategies

Barrier	ERIC-endorsed implementation strategies
Infection control has no priority at the hospital level	Conduct local consensus discussions; identify and prepare champions; alter incentive/allowance structures; access new funding; assess for readiness and identify barriers and facilitators
The role of link nurses is not defined	Make training dynamic; identify and prepare champions; promote adaptability; develop educational materials; create a learning collaborative
ICLN are not accepted by medical staff	Identify and prepare champions; inform local opinion leaders; conduct educational meetings; facilitation; assess for readiness and identify barriers and facilitators
ICLN programs are initiated, developed and implemented solely by infection control practitioners	Identify and prepare champions; develop a formal implementation blueprint; conduct ongoing training; assess for readiness and identify barriers and facilitators; develop and implement tools for quality monitoring
Responsibility to educate link nurses lies with infection control practitioners	Identify and prepare champions; inform local opinion leaders; identify early adopters; conduct local consensus discussions; create a learning collaborative
Interconnecting link nurses from various departments to exchange experiences and best practices is challenging	Organize clinician implementation team meetings; conduct local consensus discussions; build a coalition; promote network weaving; facilitation
Only half of link nurse programs are evaluated	Develop and implement tools for quality monitoring; audit and provide feedback; develop and organize quality monitoring systems; facilitate relay of clinical data to providers; obtain and use patients/consumers and family feedback

DISCUSSION

Barriers that may affect the efforts of infection control practitioners to implement a link nurse program require careful consideration. This study highlights the major importance of characteristics of the implementing organization and the stages of implementation; these are the implementation research domains inner setting and process. These two domains appear as main influencers of successful implementation of link nurses programs to improve infection prevention in acute care hospitals. Application of the CFIR-ERIC tool provides several key insights regarding the strategies to guide the implementation of these programs.

First, the most prominent strategy is the identification and preparation of champions. This single strategy addresses multiple barriers in the 'inner setting' and in the process domain (e.g. lack of priority for infection prevention, lack of acceptance of the link nurse role, variation in support for link nurse) by cultivating commitment, reducing resistance and fostering tension for change. The importance of champions is underlined by previous research that emphasizes the importance of leadership engagement and influential roles when implementing quality or

health improvement initiatives [16-18]. The role of champions also aligns with our earlier suggestions to involve key stakeholders to support the program and the link nurses at the hospital and ward level[2, 6]. Champions, individuals that have informal influence, can help to overcome resistance that may hamper the adoption or the implementation of a link nurse program within the hospital when they actively support the intervention during implementation[14]. To identify champions, Warrick recommends to start by identifying a few individuals throughout the hospital that already have the reputation of being a champion[19]. This identification can be facilitated by self-nomination or peer-nomination because sustained commitment is important during the adoption and implementation phase[20, 21]. There is no consensus in the literature on how to effectively prepare champions for their role; in addition the way the champions role is operationalized can differ[22]. Bonawitz and colleagues suggest that the skills of effective champions can be learned[23]. Others indicate that some qualities and competences cannot be taught[20, 22, 24]. Sustained and enthusiastic advocating the program, communicating the purpose and scope of the program, convincing others that the intervention is important and worthwhile, and leading by example are successful behaviours of champions that support implementation of quality improvement interventions in various health care settings[15, 20-22, 24]. These attributes should be kept in mind when in search for champions.

Second, the key barriers in the process domain relate to the somewhat improvident approach of link nurse program implementation. ICLN programs often start with and get stuck in the 'do' phase, reflecting poor planning, engaging and failing to monitor and evaluate the effects of the program[4, 25]. Several ERIC strategies can be used to improve this approach and help to shape a ICLN program Plan-Do-Study-Act cycle. A new insight provided by the matching tool, for example, is the use of needs assessments[26]. This is an important strategy that will inform and provide input during the planning phase, and adds to the formation of the implementation plan and program blueprint. As an additional strategy, Perry et al. advise to discuss these plans with stakeholders to obtain feedback[27]. Infection control practitioners could benefit from this strategy by incorporating these needs assessments and obtaining stakeholder feedback in their Plan-Do-Study-Act cycle. Iteratively assessing the needs of wards, being open to change and refining the link nurse program and the strategies to its implementation will increase the chance of success[28]. To measure success, it is important to monitor implementation quality as well as the effects on infection prevention measures and outcomes[28, 29].

The role of the infection control practitioner as a key stakeholder in the implementation of ICLN programs has not been described in previous literature. Therefore, a third important implementation strategy to consider is to invest in facilitation; this comprises both a strategy and a role for the infection control

practitioner[27]. By providing support, an infection control practitioner can enable link nurses and wards to implement infection prevention policies. Facilitation is complex as the support should be tailored to the local needs of each ward and link nurse. Thus, the infection control practitioner should be able to consciously choose from various support strategies, methods or techniques and balance the level and intensity of their support[30]. Therefore, infection control practitioners should master a range of competences. Key attributes to facilitation are interpersonal skills (e.g. flexibility, tact and sensitivity), skill in communication (e.g. conflict management and negotiation), skills in leadership (e.g. strategic thinking, responsiveness and commitment), skills in project management and skills in education[31-34].

A strength of the current study is that previously mentioned barriers regarding implementation of link nurse programs were discussed among a Delphi panel and mapped on a relatively new tool developed by implementation experts worldwide. However, Delphi panels do not provide right or wrong answers and consensus does not mean the correct answer is given. Furthermore, the effectivity of strategies that the CFIR-ERIC tool produces have not been broadly evaluated and should be tested to show if sufficient to guide local implementation efforts[35]. Therefore, we recommend each hospital to develop an implementation strategy, based on barrier-specific ERIC strategies as found in our study, and to include experts in the prioritization and operationalization of the strategies. For further operationalization of these implementation strategies it is advised to follow the reporting guidelines from Powell et al. (2013), whereby the actor, action, target, temporality, dose, implementation outcome affected and justifications are specified[36]. Future research should investigate the process of selecting and tailoring these strategies in various contexts and should test these strategies themselves.

CONCLUSION

This study highlighted the CFIR domains inner setting and process as influential on infection prevention guideline implementation with the help of link nurses programs in acute care hospitals. Application of the CFIR-ERIC tool points to the identification and preparation of champions as the leading strategy to lever the implementation of ICLN programs. Our findings can help implementation planning efforts when starting an ICLN program but cannot substitute the context specific analysis of implementation needs. Further strategies can be tailored to various clinical contexts with the help of the identified barriers and the use of the tool.

SUPPLEMENTARY MATERIAL

Additional and barrier-specific ERIC strategies

Here we present the ERIC strategies that could support specific barriers to implementation of ICLN programs based on the CFIR constructs that were matched to these barriers. We operationalize the additional found strategies, the strategies that were not listed in the overall top 10 strategies.

Barriers	**ERIC strategies that contribute to the combination of barriers**									**Additional barrier-specific ERIC strategies**									
	identify and prepare champions	conduct local consensus discussions	assess for readiness and identify barriers and facilitators	inform local opinion leaders	facilitation	create a learning collaborative	develop a formal implementation blueprint	build a coalition	identify early adopters	create a learning collaborative	alter incentive/allowance structures	access new funding	make training dynamic	promote adaptability	develop educational materials	conduct educational meetings	conduct ongoing training	develop and implement tools for quality monitoring	organize clinician implementation team meetings	promote network weaving	audit and provide feedback	develop and organize quality monitoring systems	facilitate relay of clinical data to providers	obtain and use patients/consumers and family feedback
Infection control has no priority at the hospital level	x	x	x								x	x												
The role of link nurses is not defined	x					x							x	x	x									
ICLN are not accepted by medical staff	x		x	x	x											x								
ICLN programs are initiated, developed and implemented solely by infection control practitioners	x		x				x										x	x						

Barriers	ERIC strategies that contribute to the combination of barriers										Additional barrier-specific ERIC strategies										
	identify and prepare champions	conduct local consensus discussions	assess for readiness and identify barriers and facilitators	inform local opinion leaders	facilitation	create a learning collaborative	develop a formal implementation blueprint	build a coalition	identify early adopters	create a learning collaborative	alter incentive/allowance structures	access new funding	make training dynamic	promote adaptability	develop educational materials	conduct educational meetings	conduct ongoing training	develop and implement tools for quality monitoring	organize clinician implementation team meetings	promote network weaving	audit and provide feedback	develop and organize quality monitoring systems	facilitate relay of clinical data to providers	obtain and use patients/consumers and family feedback
Responsibility to educate link nurses lies with infection control practitioners	x	x		x					x	x														
Interconnecting link nurses from various departments to exchange experiences and best practices is challenging		x			x	x													x	x				
Only half of link nurse programs are evaluated																		x			x	x	x	x

Barrier 1: Infection control has no priority at the hospital level

In addition to 1) discuss the importance of infection prevention with key stakeholders, 2) identify and prepare champions, and 3) assess the hospitals readiness, the ERIC tool proposes two strategies. To access new funding and to alter incentives to reduce the lack of priority for infection prevention. Both strategies are not viable for infection control practitioners. There is no direct mandate at hospital level for infection control practitioners to shift funding from one program

to another. Neither can infection control practitioners directly incentivize the adoption and implementation of ICLN programs with financial strategies. It is however an option to lobby for infection prevention with the help of stakeholders.

Barrier 2: The role of link nurses is not defined

Clarification of the link nurse role can be facilitated by creating a learning environment for link nurses and by champions that actively support link nurse in the uptake of their role. In addition, the following strategies can be considered.

Make training dynamic

The training of link nurses should be innovative, interactive and delivered through different methods. It will help ICLN with different learning styles to take in information and become actively involved. It will help link nurses to become skilled and enthusiastic and it will keep them engaged. If new skills can be trained and tested ICLN will become more confident in the execution of their role and their ability to achieve the program goals.

Promote adaptability

The link nurse role might need to be tailored to meet the needs of specific wards or even to the competences of the individual link nurse. This will add to the quality of the program because it will make the role more easy to adopt and maintain for link nurses. It will also make the ICLN program more accessible to wards.

Develop educational materials

To help link nurses in assuming their role infection control practitioners could distribute educational materials that can be used by the link nurses on their wards. A written role profile could be part of a guideline or toolkit on how to execute the link nurse role. Perfectly designed materials will be easy to access by link nurses and it will promote the use and the success of the program .

Barrier 3: ICLN are not accepted by medical staff

Conduct educational meetings

Champions of the program can help to inform and educate the medical staff about the ICLN role. It can help to overcome resistance and to influence the attitude of medical opinion leader towards the program. Make sure to inform staff about the way the program is intended. Familiarity with the details and underlying principles of the program can have a positive influence on their attitude.

Barrier 4: ICLN programs are initiated, developed and implemented solely by infection control practitioners

The main results of this study show that champions can influence the organizational culture, a critical barrier to leveraging infection prevention knowledge and implementing a ICLN program. A formal implementation blueprint will help to plan and execute the implementation. This plan needs to include actions to promote the effective implementation and to build local capacity for adopting the ICLN program. It will help to influence the organizational culture. Extra proposed strategies to tackle this barriers are:

Conduct ongoing training

Describe all components of training for the link nurse program, make sure make to repeat training sessions and to make its schedule dynamic. It will help to accommodate and involve the whole link nurse group and it ensures that new link nurses can join the program at any time. By including training on the job, based on the level of knowledge of the individual link nurse, training can focus on the needs of this individual link nurse and the specific focus points of that specific ward. It will build the self-efficacy of link nurses and support them to carry out the implementation of infection prevention according to plan.

Develop and implement tools for quality monitoring

Infection control practitioners can benefit from quality monitoring tools by presenting infection prevention measures and outcomes at the hospital and the ward level. It will help to build a sense of ownership for the change process and it can encourage performance. The tool should be easily accessible and should show data that relates to the ICLN program. It will help to implement the program according to the implementation blueprint.

Barrier 5: Responsibility to educate link nurses lies with infection control practitioners

No additional strategies were found to address this barrier. However, the strategy to create a learning collaborative could be interpreted slightly different in the context of this specific barrier. Infection control practitioners could team up with the leaders of link nurse programs that address other quality and safety issues within the hospital. It will facilitate the connections and bonding between the program leaders. It can add to building a community for quality improvement and to the collaboration in implementation efforts.

Barrier 6: Interconnecting link nurses from various departments to exchange experiences and best practices is challenging

Two additional strategies will support the relationship and connect link nurses from different specialties and wards. It will support the sharing of information and experiences. Facilitating and supporting these relationships can have a positive influence on the implementation of infection prevention. Furthermore the turnover of link nurses is likely to be lower. Strategies to support this sense of community are:

Organize clinician implementation team meetings

Develop and support link nurses who are implementing infection prevention at the ward level. Provide them the time to reflect on their efforts and to share their lessons learned during link nurse meetings or educational sessions.

Promote network weaving

Infection control practitioners could team up with program leaders from different link nurse programs within the hospital to share information and to collaborate in training. Collaboration could facilitate the exchange of experiences and best practices between link nurse of different specialties (e.g. wound care, medication safety), of different wards. Moreover infection control practitioners could collaborate with other hospitals in the region. Connecting with others and creating networks will help to bring in new information and ideas.

Barrier 7: Only half of link nurse programs are evaluated

To monitor implementation efforts it is necessary to obtain feedback about the progress and the quality of the ICLN program and about the experiences of stakeholders with the program. Data should be generated on SMART formulated goals but should also reflect the experiences of stakeholders to improve the ICLN program along the way. To evaluate ICLN programs the ERIC tool generated the following strategies.

Audit and provide feedback

Collect data, summarize it and feedback the results to ward and link nurses to encourage performance. Cumulate data to evaluate the ICLN program and to account for the investment in time and effort at the hospital level. It can help to promote continuation of the program.

Develop and organize quality monitoring systems

To ensure the quality of the ICLN program, infection control practitioners can develop procedures to monitor the process and the outcomes of the ICN program. These procedure can guide and complement the audit and feedback cycle.

Facilitate relay of clinical data to providers

Infection control practitioners can feedback the audit data in such a way that it promotes the use of the ICLN program. Data should be shared real-time if possible.

Obtain and use patients/consumers and family feedback

A less clear cut strategy to promote the implementation of infection prevention with the help of link nurses is to incorporate patient feedback into the implementation plan and into the audit and feedback cycle. Infection prevention in general can be actively evaluated amongst patients with the help of evaluation forms. Although this information is not likely to provide any information on the implementation efforts of the link nurse of that ward, it might help to create a sense of urgency for infection prevention, at the ward level.

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CHAPTER 8

General discussion

The global burden of healthcare associated infections and antimicrobial resistance will continue to grow unless we effectively engage health care workers in the uptake of infection prevention policies. To improve adherence to infection prevention and control (IPC) measures, many IPC teams worldwide collaborate with infection prevention link nurses (ICLN).

At the Amsterdam UMC location VUmc, the Commission on Infection prevention and Antibiotics aims to minimize healthcare associated infections and to reduce unnecessary or incorrect antibiotic use. One of the projects to promote infection prevention, was the development of a program for link nurses with a special focus on infection control. This involved the setting up and implementing training for these nurses, and their further coaching to improve practice. While we researched how to set up and implement such a program, we incorporated the best available research into this project.

In this thesis we systematically described the elements that influence the successful engagement of ICLN, their role in acute care hospitals and the programs that have been developed to support ICLN. We aimed to explain how current programs could be improved to support ICLN, to evaluate the effectiveness of ICLN programs in improving compliance with infection prevention and control guidelines and, finally, to provide strategies for further implementation of these programs. The main research questions were:

I. What are the characteristics and success factors of link nurses and link nurse programs in acute care hospitals?
II. What are the effects of infection control link nurse programs on IPC processes and outcomes?
III. How can link nurse programs be effectively implemented?

Characteristics and success factors of link nurses and link nurse programs are described in **chapter 2, 3, 4, 5 and 6**. The main barriers to implementation were identified and are summarized in **chapter 7**. The domains and constructs of the Consolidated Framework for Implementation Research (CFIR) were matched to these barriers[1]. We applied the Expert Recommendations for Implementing Change (ERIC) Implementation Strategy Matching tool to identify implementation strategies that could address these barriers[2].

Characteristics and success factors of infection control link nurse programs

In 2019, ICLN programs were implemented in two-thirds of Dutch hospitals. The results from **chapter 3** show that programs to support these link nurses were initiated and developed by the infection control teams of those hospitals, leading to a wide variety in content and in ways these programs were implemented and evaluated. **Chapter 2, 3 and 4** described elements that facilitated the support of ICLN; they included a clear role profile, commitment from the infection prevention and control team, support from hospital and ward management, and contact with other ICLN.

Education was described as the core component of ICLN programs (**chapter 2 and 3**). The survey results described in **chapter 3** showed that ICLN programs were perceived as more effective when they included both education on infection prevention topics and training in implementation skills (median 7.0, IQR 7.0–8.0), as compared to programs without such education (median 5.0, IQR 2.5–6.8) or programs where education included only infection prevention topics (median 6.0, IQR 6.9–7.5). These findings are in line with previous research stating that the transfer of knowledge as a self-contained intervention is known to sort little effect[3, 4]. The dissemination of infection prevention knowledge or guidelines through education can be helpful to realize non-complex changes in daily practice[4]. However, to improve IPC guideline adherence, behavioral change is a prerequisite, and such change requires more complex strategies[4-6]. In the interviews summarized in **chapter 4**, link nurses clearly voiced their need to collaborate with ICLN from other wards and learn from each other's best practices. At the hospital level, this could mean that future ICLN programs should not only include education and training of ILCN, but should also help ICLN to connect with others in a network that encourages information sharing, fosters relationships and promotes interdepartmental collaborations. Networks with these features are considered to positively impact implementation and are associated with sustainability and the creative solving of problems[7-10].

Adaptability and flexibility of ICLN programs positively influenced the success of ICLN in implementing IPC guidelines. It allowed tailoring of ICLN program activities to align them with the needs specific to each ward and to shift focus from hospital goals to goals tailored to the ward level. This tailoring is another important element to improve the effects of ICLN programs. If stakeholders at the ward join forces, conditions are created for effective implementation of safe practices with interventions that are adjusted to local priorities, ward culture, and its context specific facilitators and barriers[11-14]. Local teams will help ICLN to feel involved in decision-making, which will promote the accountability of link nurses and their

managers; both conditions are related to the achievement of goals[15, 16]. In **chapter 6** we showed that ICLN programs can promote this accountability with the help of ward based action plans. These plans were created to fit the local context and infection prevention issues of each ward and were formulated together with the ward management, ICLN and the infection control practitioner. They helped to structure ICLNs activities (**chapter 4**).

From the interviews described in **chapter 3**, it also became clear that one of the major facilitators of the implementation of infection prevention was related to a more positive overall attitude of hospital management and health care workers towards infection prevention. It created opportunities for support to start an ICLN program. This attitude was sparked by threats such as a recent outbreak within the hospital, epidemics around the world and the rise of antimicrobial resistance. Pressure from external bodies (e.g. Joint Commission International) also urged for hospital management to address infection prevention as an integral part of patient safety and quality of care.

Despite the overall more positive attitude towards infection prevention in acute care hospitals, resources are scarce; this forced hospitals to make difficult choices[17]. The review of the literature on ICLN (**chapter 2)** showed that this scarcity of resources resulted in some hospitals in a lack of time and power allotted to link nurses and a lack of support from ward management to acknowledge and validate the link nurse role to the rest of the team. This lack of support subsequently resulted in a lack of acceptance of the link nurse role by other groups of health care workers; this became clear not only from the literature review (**chapter 2**), but also from our interviews with link nurses summarized in **chapter 5**. The lack of support and acceptance of the link nurse role limited and undermined the influence of link nurses at the ward level and led to insufficient time for link nurse activities. Conditions that are described by the European Centre for Disease Prevention and Control (ECDC) and the World Health Organization (WHO) as a core elements when organizing and managing infection prevention in hospitals PC[18, 19]. For these reasons, many ICLN programs have ceased their activities (**chapter 2 and 3**).

It has been suggested that authority is a core competence for link nurses to fulfil their role and therefore clinically experienced nurses were preferred as ICLN (**chapter 2**). The Dutch ICLNs that participated in our survey, described in **chapter 3**, did not mention their work experience as a prerequisite for their link nurse role. Likewise, the evaluation of the infection control link nurse program in our hospital did not reveal work experience as a precondition for link nurses to have impact (**chapter 6**). This is supported by our finding that, even for some experienced nurses, the uptake of their link nurse role remained complex even when provided with a written role profile, a comprehensive ICLN program, support from their

manager and a proactive infection control practitioner[20, 21]. We did find that when ICLN felt supported and inspired, they were more likely to feel empowered and consequently more likely to take impactful initiatives. These initiatives can be seen as empowering behavior which is related to professional knowledge and skills, authority, self-confidence of nurses and their commitment to their profession[22, 23]. Nurse empowerment is positively correlated with the provision of higher quality of care and better patient outcomes[24]. On the one hand, individual motivation and competencies such as empowerment should be considered when appointing new link nurses. On the other hand, investments in link nurse empowerment should be an integral aspect of ICLN programs to support them in the uptake of their role.

The role of the infection control practitioner as a key stakeholder in the coordination of ICLN programs at the hospital level and to support individual ICLN at the ward level has not been described in literature previously.

To support adoption, dissemination and implementation of infection prevention though an ILCN program, infection control practitioners need skills in selecting and designing implementation strategies for such programs[25]. Most infection control practitioners, however, are not specifically trained to develop complex interventions and to guide their implementation. As a result, effective program elements and strategies that support implementation are not sufficiently applied (**chapter 3**). To support link nurses in their efforts to implement infection prevention within their specific ward, infection control practitioners should master skills in facilitation and knowledge brokering[25-28]. Skills that should be taught during a dedicated training program of infection control practitioners.

Effects of infection control link nurses on IPC processes and outcomes

The results of our literature review in showed that most studies only report on the improvement of awareness for infection prevention, after the implementation of ICLN programs. We found a few studies that evaluated the introduction of ICLN with respect to infection rates; these studies all showed a reduction in the number of healthcare-related infections. In three studies clinical practices improved with the help of ICLN (**chapter 2**). From the interviews reported in **chapter 4** it transpired that to improve practice, link nurses adjusted and operationalized infection prevention policies into workable instructions to fit the conditions of their specific wards and provided practical instructions and feedback to their peers; this enabled better fit of guidelines and beter compliance with infection prevention policies. These context-specific process improvements contribute to safer care, but may not show in measurements on guideline adherence at the hospital level. Prioritization of infection prevention topics was based on the considerations of

link nurses and therefore varied per ward. This might explain why there are only a few reports on the effects of ICLN programs. This thesis adds to the body of evidence on the effects of ICLN on clinical practice with the results of two studies. In **chapter 5** the overall compliance to a hospital dress code increased by 39.6% (95% CI 31.7–47.5) after implementation of a ICLN program. The thoroughly evaluated ICLN program presented in **chapter 6** showed that the program helped ICLN to improve infection prevention practices, especially in inpatient wards.

Effective implementation of infection control link nurse programs

The success of ICLN program implementation depends on the ability of infection control practitioners that lead ICLN programs to recognize hindering and facilitating factors to subsequently effectively addressed these factors. In **chapter 7** the current barriers to implementation of ICLN programs in acute care hospitals were summarized. Main barriers related to the development of the program and to how the program was implemented. Barriers corresponded predominantly with constructs from the CFIR domains inner setting (characteristics of the implementing organization) and process (stages of implementation). None of the barriers corresponded with constructs from the domain outer setting (external influences on the implementation). Application of the CFIR-ERIC tool pointed towards two main groups of strategies for improvement namely, to develop stakeholder interrelationships to support cultural change and to use evaluative and iterative strategies to address the various areas of system change and monitoring and feedback.

To engage stakeholders in the process of implementation, first a stakeholder analysis is needed to discern the roles and relationships of stakeholders involved in ICLN programs[29]. Such analysis provide a clear overview of the degree of influence, involvement and interests of these groups. Second, champions can help to overcome resistance that may hamper the implementation, shift the perception of key stakeholders and influence individuals in an organization who formally or informally influence the attitudes and beliefs of their colleagues. Champions are individuals that have informal influence and actively support the link nurse program during implementation. They can influence the organizational culture, which is a critical barrier to leveraging infection prevention knowledge and implementing a ICLN program.

ICLN programs often start with and get stuck in the ‘do’ phase, reflecting poor planning, engaging and failing to monitor and evaluate their effects of the program[30]. It is better to think of ICLN programs as not set in stone but rather as an ongoing learning process to improve and refine the collaboration. That way ICLN

programs can tweak elements to keep meeting the needs of individual link nurses and with new needs and challenges in IPC at the hospital level. Implementation strategies such as the iterative assessment of the needs of wards, obtaining stakeholder feedback, monitoring implementation quality and measuring success can be used to shape and repeat Plan-Do-Study-Act cycles[31-34].
It is widely recognized that improving guideline adherence requires behavioral change; such change requires complex strategies[4, 35, 36]. These strategies usually combine several activities, that are implemented in an integrated way. Considering our findings in the light of recommendations made by the World Health Organization, we suggest that ICLN programs should include a implementation plan with strategies that are tailored to the local context such as a full quality improvement cycle and strategies to engage the hospital and ward management and other stakeholder[37, 38].

Infection control link nurse programs through the lens of implementation science

Many frameworks exist within the field of implementation science[39]. Frameworks allow to investigate an implementation in a structured way. The Consolidated Framework for Implementation Research (CFIR) is a comprehensive framework produced by evaluating and combining key constructs from nineteen published implementation theories[1]. In this thesis the CFIR was used to understand and explain the critical elements of ICLN programs and to identify opportunities to maximize their impact on the uptake of IPC guidelines. The use of this framework mitigated the risk of overlooking important elements.

The CFIR describes five domains, including the *intervention characteristics*, the *inner setting*, the *outer setting*, comprising the *characteristics of the individuals* involved and the *process of implementation*. Influential elements, relevant for the implementation of ICLN programs were found for all of these domains. Some of the success factors that were found were the exact opposite of barriers. For instance, the support from the ward manager helped link nurses to take impactful initiatives, while a lack of support hindered the acceptance of their link nurse role by other health care workers. Figure I. provides an overview of success factors and implementation strategies by the domains of the CFIR.

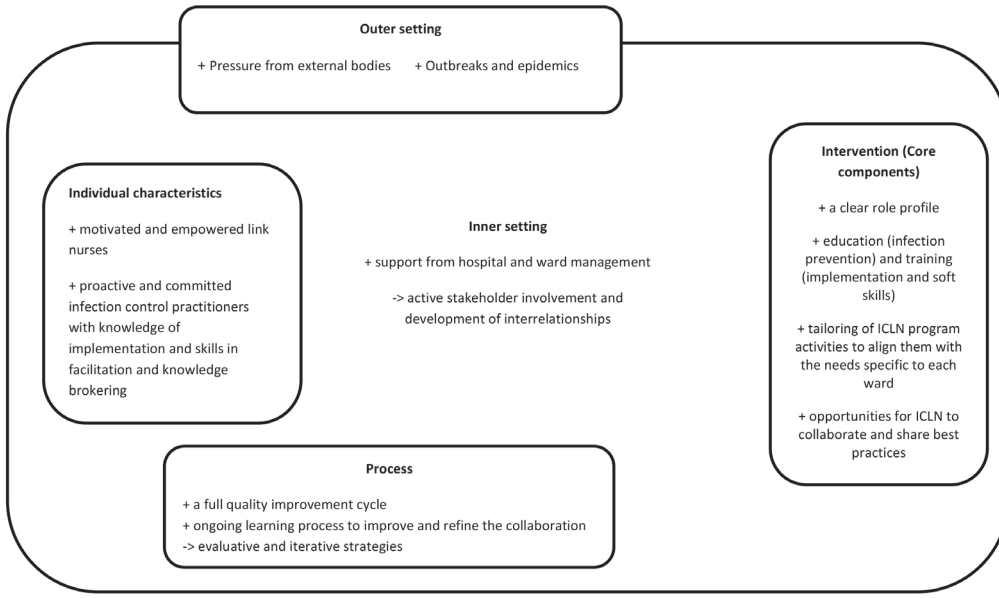

Figure I. Overview of success factors (+) and implementation strategies (->) by the domains of the Consolidated Framework for Implementation Research

Overall, the CFIR helped to define what elements can facilitate the impact of ICLN. In addition, the application of the CFIR-ERIC tool provided useful strategies to support implementation of ICLN programs. The RE-AIM model helped to assess the implementation outcomes of the infection control link nurse program in our hospital. It underpins the necessity to combine theories, models, frameworks for understanding and explaining the many influences on implementation of IPC with the help of link nurse. Classic theories from sociology (such as social networks theories and social capital theories) and implementation theories (such as Capability Opportunity Motivation-Behavior model and Normalization Process Theory) could help to specify the relations between these elements or their degree of influence.

Methodological considerations

Researching infection control link nurses with my background in nursing, as a former infection control link nurse, as infection control practitioner and as project leader of the infection control link nurse program at Amsterdam UMC location VUmc, had several advantages and some challenges too. Being a direct colleague made it quite easy to recruit infection control practitioners and link nurses as participants for the interviews. Handing out questionnaires among colleagues

during a national congress and collecting them the same day worked like a charm to reach an excellent response rate. One of the challenges was to interview link nurses and infection control practitioners and analyze these interviews without preconceptions and assumptions. Therefore reflexivity was an important element during this research. Reflexivity is an assessment of the influence of team members' backgrounds, their interests in the research topic and their perceptions on the research process. It reduces the risk of being guided by team members' knowledge, experiences and expectations[40]. The discussions with the research team, the involvement of other researchers who were unfamiliar with participants and audit trails helped me to maintain awareness of my preunderstandings and how these could affect the findings during both the interviews and data analyses.

The studies presented in this thesis have several strong elements. First, we used a variety of research methodologies. Triangulation of methods and data sources enabled us to interpret the findings by looking at it from different perspectives. Second, we used the CFIR to structure our findings, which resulted in a comprehensive overview of facilitators and barriers to the implementation of ICLN programs in acute care hospitals. The proposed strategies to improve implementation were grounded in theory. This facilitates the use of these strategies, with only a few adjustments to fit the local context.

The main limitation of the questionnaire and the interview studies with infection control practitioners and infection control link nurses is that the outcomes were based on self-reported outcomes and self-reported effects of ICLN programs or link nurse activities. Although the literature review and the evaluation of the Amsterdam UMC, location VUmc program showed outcomes related to the reduction of HAI and the increase of compliance with infection prevention policies (**chapter 2, 5 and 6**), the exact effects of ICLN programs in a variety of contexts remain unassessed.

Future directions

Implementation is an important task of IPC teams. The collaborations with link nurses to achieve implementation of IPC is popular in acute care hospitals, which makes ICLN and the programs that support these nurses an important topic. Such programs are developed locally, by infection control practitioners, resulting in a wide variety of content. The implementation and evaluation of these programs also varies. The local nature of programs can partially explain why the existing knowledge about effective elements of ICLN programs is not used. In addition, infection control practitioners are not specifically trained to develop complex interventions and to guide their implementation. Therefore, hindering and facilitating factors are not always recognized nor effectively addressed. Programs

often pertain to the education of link nurses. The studies presented in this thesis provide an overview of elements that facilitate or impede the impact of ICLN programs and provide strategies to support the implementation of these programs. Considering the advantages of awareness of infection prevention and the potential to improve clinical practice, link nurses and the accompanying programs deserve a place as a core component of IPC programs in acute care hospitals. However, to maximize the impact of link nurses, we need to transform our ICLN programs into a more effective intervention, to engage in effective implementation methods, and to create a context that enables ICLN to disseminate and implement their knowledge. Therefore it is imperative to design infection control link nurse programs as multimodal interventions; their implementation should be guided by evidence informed strategies. In addition, infection control practitioners should invest in training of implementation and interpersonal skills. It is only then that link nurse programs can sufficiently support link nurses in the completion of their task.

Implications for practice

The core component of ICLN programs is the education of link nurses. In general, this education focusses on IPC knowledge. ICLN programs should also focus on elements that strengthen the resilience of link nurses and empower them. Both these competencies are associated with the provision of safe care. Infection control practitioners should involve implementation experts and coaches to improve personal leadership skills in link nurses to execute these trainings and require implementation expertise themselves. It will help ICLN to adjust infection prevention guidelines to fit the context of their ward. This way ICLN programs can shift their focus from dissemination to implementation of IPC in daily practice.

This shift to a flexible application of infection prevention aligns with the concepts of the Safety II perspective on healthcare. Safety II facilitates a positive approach with health care workers at the centre that accepts variation, embraces variability in protocols and encourages flexible ways of working[41, 42]. Link nurses that can mindfully adapt IPC guidelines can be referred to as resilient or empowered health care workers[24, 43]. With the pressure to provide high quality and complex patient care, resilience is a vital competence for nurses in today's health care system.

The performance of link nurse is also influenced by the availability of infection control practitioners, which consequently will be influenced by all other IPC activities, the capacity of the IPC team and the existing policies[37]. Therefore, ICLN programs should be considered as an integral component of infection prevention and control programs and not as a self-contained project. To date, IPC is no longer limited to the tasks of guideline development, surveillance and education.

In 2012, collaboration with experts in the field of implementation science was already advocated by Spijkerman et al[44]. However, a stronger approach would be to incorporate this expertise in IPC teams. It would help to actively apply this knowledge in daily IPC projects and activities.

Implications for research

The implications for future research involves studies to provide robust evidence on the effectiveness of ICLN programs, the application of participatory action research and human-centered design techniques to learn from implementation of these findings in real world settings, the investigation of how ICLN programs can transform into networks using social network theory and to study the influence of individual characteristics of nurses on the adoption of their link nurse role.

To understand how ICLN programs, in which effective elements and evidence-based implementation strategies are integrated, can be implemented and can sustain in real world settings, comprehensive monitoring and evaluation are prerequisites. It is therefore recommended to collect experiences from various stakeholders, learn from different perspectives and reflect on best practices when implementing these finding in multiple acute care hospitals. This process of participatory action research or human-centered design techniques will fit the needs of the users and will take into account the hospital dynamics in which these users operate[45-49]. It will help to translate the findings from this thesis, the knowledge on facilitating and impeding factors, and evidence-based implementation strategies into a broader applicable and effective ICLN program and a blueprint for implementation. This process can help to further expand our knowledge on optimizing effectiveness and implementation of link nurse programs and our understanding of its potential for implementation at scale. It will help us to understand the applicability of the ICLN program in daily practice and it will strengthen its scientific underpinning. This approach can also help to adapt and test ICLN programs to be applicable in other settings, such as long term care facilities.

Second, it would be interesting to apply the social network theory to investigate how ICLN programs can transform into networks. ICLN programs that facilitate ICLN to connect within a network can influence the social support, work engagement of link nurses and their job satisfaction. Boundary-crossing networks with these features are considered to positively impact clinical practice and are associated with sustainability and the creative solving of problems.

In addition, we should study how individual characteristics of link nurses influence the uptake of actions related to the link nurse role. Human centered design techniques (e.g. journey mapping and personas), can explicate the emotions of link nurses regarding their role, the context and interactions with other health care workers that influence link nurses in assuming their role. It can help to tailor elements of ICLN programs to fit the needs of individual link nurses.

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SUMMARY

Infection control link nurses (ICLN) act as a link between colleagues in their own clinical area and the infection prevention and control team. They help to raise awareness for infection control by educating colleagues and motivating them to improve practice. To fulfil this role, link nurses are trained by infection control practitioners. Programs to train and support ICLN vary in the way they are organized and implemented. In this thesis, the elements that influence the successful engagement of ICLN in acute care hospitals were systematically explored and described. The aim was to explain how current programs could be improved to support ICLN, to evaluate the effectiveness of ICLN programs in improving compliance with infection prevention and control guidelines and, finally, to provide strategies for further implementation of these programs.

The first part of this thesis, **chapter 2, 3 and 4**, focused on the characteristics and success factors of link nurses and link nurse programs in acute care hospitals.

In **chapter 2** the role of infection control link nurses, infection control link nurse programs and their effects were evaluated, and gaps in the evidence base were identified. Involving link nurses in infection prevention and control has been implemented in hospitals worldwide to improve clinical practice. We aimed to identify key elements of infection control link nurses (ICLN) and ICLN programs, to evaluate the effect of such programs, and to identify gaps in the evidence base. In a scoping review, 29 research- and opinion-based papers on ICLN in acute care hospitals were included. Three key elements were identified: the profile of ICLN, strategies to support ICLN, and the implementation of ICLN programs. The majority of included studies delineated the ICLN profile with accompanying roles, tasks and strategies to support ICLN, without a thorough evaluation of the implementation process or effects. Few studies reported on the effect of ICLN programs in terms of patient outcomes or guideline adherence, with positive short-term effects. This review revealed a lack of robust evidence on the effectiveness of ICLN programs. Best practices for an ICLN program included a clear description of the ICLN profile, education on infection prevention topics as well as training in implementation skills, and support from the management at the ward and hospital level.

In **chapter 3** the variation and success factors in infection control link nurse programs in Dutch acute care hospitals were assessed. At that time, the Netherlands had 74 hospitals. In a mixed-methods study, 72 infection control practitioners from 72 different hospitals were surveyed. The outcomes of the survey were supplemented with four additional semi-structured interviews. The survey was based on items of the Template for Intervention Description and Replication (TIDieR) checklist. A link nurse program was present in 67% of the

hospitals; responsibility for 76% of these programs lied solely with the infection prevention and control team. The core component of most programs (90%) was education. Programs that included education on infection prevention topics and training in implementation skills were perceived as more effective than programs without such education or programs where education included only infection prevention topics. The interviews illustrated that these programs were initiated by the IPC team with the intention to collaborate with other departments to improve practice. Content for these programs was created at the time of their implementation. Infection control practitioners varied in their ability to express program goals and to engage experts and key stakeholders. From the interviews it transpired that infection control practitioners seemed more satisfied if they were able: 1) to express a more coherent vision and more long-term strategic goals, 2) to involve more experts (e.g. educational experts) in the enhancement of their program, and 3) to engage more key stakeholders, including management, and their direct colleagues, the IPC team, to create support.

Few studies have assessed the way link nurses themselves perceive their role; how they fulfil it, how they increase and disseminate their knowledge, what difficulties they encounter, and what supports them in advocating infection prevention in clinical practice. Examining these issues could provide better insight in how ICLN contribute to the improvement of infection prevention at the ward level and how ICLN programs could optimally facilitate these contributions. In **chapter 4** the role perception and work requirements of ICLN were assessed. A qualitative study was conducted; 26 semi-structured individual and 4 focus group interviews were performed with ICLN from five acute care hospitals. The effect of COVID-19 on the ICLN role was added as a topic in focus group interviews during the pandemic. From the thematic analysis it emerged that ICLN perceived their role as to identify, monitor, facilitate and inform their colleagues on infection prevention topics related to their ward. Their experiences varied from feeling challenged and wondering how to get started, to feeling confident and taking initiatives that lead to ward-based improvements. During the COVID-19 pandemic, ICLN felt their responsibilities were magnified. When transferred to another ward, the focus on the ICLN role seemed dispersed. When inspired by each other and supported by infection control practitioners or managers, ICLN felt empowered to initiate more activities to improve practice. With these preconditions in place, ICLN were more likely to take impactful initiatives that contributed to the uptake of safe practices at the ward level. Therefore, activities to improve resilience and the empowerment of ICLN were recommended as one of the pillars of ICLN programs.

In **chapter 5 and 6,** the second part of this thesis**,** the results of the ICLN program in a university hospital were evaluated.

Proper hand hygiene is hindered by rings, wristwatches and long sleeves. Through jewelry, artificial nails and clothing, health care workers can transfer microorganisms to patients, colleagues or themselves. Therefore, a hospital dress code has been defined in a university hospital in the Netherlands for health care workers in direct patient care. The effectiveness of the ICLN program on compliance with the hospital dress code was described in **chapter 5**. In this single center longitudinal study the compliance with the dress code was measured. Between March 2014 and June 2016, in total 1920 health care workers were observed in hospital hallways for adherence to the policy. Link nurses were invited to discuss causes of (non) compliance based on the outcome of the baseline measurement and prioritize possible solutions with their colleagues. A lack of knowledge, lack of facilities, and negative attitudes were identified as main causes for non-compliance. Tailored interventions targeted at these causes increased overall compliance with 39.6% (95%CI 31.7-47.5) from 42.5% to 65.4%.

In **chapter 6**, the impact of a ICLN training and support program was explored. We organized the outcomes of this study along the five dimensions of the RE-AIM framework: Reach, Effectiveness, Adoption, Implementation and Maintenance. Data was collected from stakeholders, from project documents and through direct observations, questionnaires, and interviews. Between 2014 and 2018, on average 91% of the inpatient wards and 58% of the outpatient clinics participated in the program (Reach) and impacted guideline adherence in inpatient wards. Link nurses felt engaged and empowered, and perceived their contribution to these results as pivotal. Ward managers confirmed the value of ICLN to help with implementing IPC practices (Effectiveness). The program was adopted both at the hospital and at the ward level (Adoption). Program principles were highly valued at the organizational level and the program was used as a blueprint for link nurse programs in other disciplines. Based on ongoing evaluations, the program was adapted by refining education, training and support strategies with emphasis on ward specific aspects (Implementation). The ICLN program was described as a key component of the infection prevention policy to sustain its effects (Maintenance). The program helped ICLN to improve infection prevention practices, especially in inpatient wards. The key to these improvements laid within the adaptability of the program. It allowed tailoring of program activities to align them with the needs specific to each ward.

The third part of this thesis, **chapter 7 and 8**, provided a synthesis of the results and a general discussion on infection control link nurses and the programs that support these nurses.

Infection control practitioners face several challenges when implementing infection control link nurse (ICLN) programs. Identification of strategies to address

these can improve the impact of current ICLN programs and guide their future implementation. In **chapter 7,** the main barriers to the implementation of ICLN programs were identified and are summarized; the Consolidated Framework for Implementation Research (CFIR) domains and constructs were matched to these barriers. An expert panel matched 19 implementation and sustainment barriers, identified in the previous studies, to the most fitting CFIR constructs. The CFIR - Expert Recommendations for Implementing Change (ERIC) Implementation Strategy Matching tool was applied to identify implementation strategies that could address these barriers. Barriers were predominantly found within the CFIR domains inner setting, (characteristics of the implementing organization) and process (stages of implementation). With the ERIC Matching Tool, the ten most important strategies were identified to lever the implementation of ICLN programs. These strategies were to 1) identify and prepare champions, 2) conduct local consensus discussions, 3) assess for readiness and identify barriers and facilitators, 4) inform local opinion leaders, 5) use facilitation, 6) create a learning collaborative, 7) conduct a local needs assessments, 8) develop a formal implementation blueprint, 9) build a coalition, and 10) identify early adopters. These findings can help implementation planning efforts when starting an ICLN program but cannot substitute the context specific analysis of implementation needs. With the CFIR-ERIC tool, strategies can be specifically tailored towards local implementation and sustainment barriers.

In **Chapter 8,** the studies presented in this thesis were put in a broader perspective. Characteristics and success factors of link nurses and link nurse programs in acute care hospitals were described, the effects of infection control link nurse programs on IPC processes and outcomes were summarized and strategies to effectively implement ICLN program were given. The findings from this thesis support the investment in link nurses and the accompanying programs: ICLN raise awareness of infection prevention and have the potential to improve clinical practice in acute care hospitals. ICLN programs are yet not aligned, they vary widely in content and organization. Elements that facilitated the support of ICLN included a clear role profile, commitment from the infection prevention and control team, support from hospital and ward management, education on infection prevention topics in combination with implementation skills and contact with other ICLN. At the ward level action plans helped to structure ICLNs' activities. Two main implementation strategies were found to support implementation: the development of stakeholder interrelationships to support cultural change and the use evaluative and iterative strategies to address the areas of system change and monitoring and feedback.

In view of these findings, future research should include studies to provide robust evidence on the effectiveness of ICLN programs, the application of participatory action research and human-centered design techniques to learn

from implementation of these findings in real world settings, the investigation of how ICLN programs can transform into networks using social network theory and to study the influence of individual characteristics of nurses on the adoption of their link nurse role.

SAMENVATTING

Contactpersonen voor infectiepreventie (CIP) zijn verpleegkundigen met extra aandacht voor infectiepreventie. Ze vergroten het bewustzijn voor infectiepreventie op de eigen afdeling en motiveren collega's om infectiepreventiemaatregelen toe te passen. CIP worden bij hun activiteiten ondersteund door deskundigen infectiepreventie met lokaal opgezette programma's. Deze programma's variëren in de manier waarop ze zijn georganiseerd en worden uitgevoerd.

In dit proefschrift is onderzocht welke elementen de succesvolle inzet van CIP in ziekenhuizen beïnvloeden. De manieren waarop de huidige programma's ter ondersteuning van CIP kunnen worden verbeterd zijn onderzocht en de effectiviteit van deze CIP programma's bij het verbeteren van de naleving van richtlijnen voor infectiepreventie zijn geëvalueerd. Ook de barrières t.a.v. de inzet van CIP en CIP programma's zijn onderzocht en passende implementatiestrategieën zijn beschreven.

Het eerste deel van dit proefschrift, **hoofdstukken 2, 3 en 4**, richt zich op de kenmerken en succesfactoren van CIP en CIP programma's in ziekenhuizen.

In **hoofdstuk 2** is de rol van de CIP, de programma's die deze CIP ondersteunen en de effecten van deze programma's geëvalueerd. In een scoping review werden 29 onderzoeks- en opiniepapers over CIP in ziekenhuizen uit vijf continenten opgenomen. Dit laat zien dat de samenwerking met CIP ter verbetering van de klinische praktijk in ziekenhuizen over de hele wereld wordt toegepast. De meeste papers schetsten het CIP profiel met bijbehorende rollen, taken en strategieën ter ondersteuning van CIP, zonder een evaluatie van het implementatieproces of van de effecten van CIP programma's. Belangrijke onderdelen van succesvolle CIP programma's waren voor een CIP programma waren een duidelijke beschrijving van het CIP profiel, onderwijs over infectiepreventie, training in implementatievaardigheden en steun vanuit het management op afdelings- en ziekenhuisniveau. Slechts een paar studies rapporteren over het effect van CIP programma's op patiëntuitkomsten of richtlijnnaleving, deze beschrijven positieve effecten (korte termijn). Er is weinig onderzoek gedaan naar de effecten van CIP programma's. De impact van CIP en bijpassende programma's op het voorkomen van ziekenhuisinfecties is ook moeilijk te beoordelen, omdat de uitkomsten wordt beïnvloed door vele andere factoren. Daarom is het gerechtvaardigd dat toekomstige studies zich richten op surrogaateindpunten zoals: het bewustzijn van het belang van infectiepreventie, kennis van infectiepreventie en de naleving van richtlijnen. Duidelijk is ook dat er weinig bekend is over de manier waarop CIP het beste kunnen worden ondersteund bij het verspreiden van kennis en het creëren van verandering in de praktijk op hun afdeling en over de contextuele factoren die van invloed zijn op CIP programma's.

In **hoofdstuk 3** zijn, met een mixed-methods onderzoek, de succesfactoren en de variatie in CIP programma's in Nederlandse ziekenhuizen in kaart gebracht. Nederland telde op dat moment 74 ziekenhuizen. Eerst vulden 72 deskundigen infectiepreventie uit evenveel ziekenhuizen een vragenlijst in, gebaseerd op de items van de checklist Template for Intervention Description and Replication (TIDieR). De uitkomsten van deze vragenlijst zijn aangevuld met semigestructureerde interviews. Uit de vragenlijst bleek dat in 67% van de ziekenhuizen een CIP programma aanwezig was; de verantwoordelijkheid voor 76% van deze programma's lag uitsluitend bij het infectiepreventieteam. De kern van de meeste CIP programma's (90%) was onderwijs. Programma's die trainen op inhoud (infectiepreventie) én op implementatievaardigheden, werden als effectiever beschouwd dan programma's zonder training of programma's waarin alleen infectiepreventieonderwijs was opgenomen. Uit de interviews bleek dat CIP programma's zijn geïnitieerd door het infectiepreventieteam met de bedoeling om structureel samen te werken met andere afdelingen aan de preventie van infecties in de dagelijkse praktijk. De inhoud voor deze programma's wordt gelijktijdig met de implementatie ontwikkeld. Deskundigen infectiepreventie varieerden in hun vermogen om programmadoelen te verwoorden en andere belanghebbenden te betrekken. Uit de interviews bleek dat deskundigen infectiepreventie tevredener leken over de uitkomsten van deze programma's als ze in staat waren: 1) een meer coherente visie en meer strategische doelen voor de lange termijn te beschrijven, 2) meer experts (bijvoorbeeld op het gebied van onderwijs) te betrekken bij de verbetering van hun programma, en 3) om meer belanghebbenden, waaronder het management en directe collega's uit het infectiepreventieteam, te betrekken om draagvlak te creëren.

In **hoofdstuk 4** zijn de perceptie en randvoorwaarden t.a.v. de CIP rol beschreven vanuit het perspectief van CIP zelf. Er is onderzocht hoe verpleegkundigen zelf over de CIP rol denken; hoe ze deze invullen, hoe ze hun kennis vergroten en verspreiden, tegen welke moeilijkheden ze aanlopen en wat hen ondersteunt bij uitdragen van infectiepreventie in de praktijk. Het doel was om beter inzicht te krijgen in hoe CIP bijdragen aan de toepassing van infectiepreventie op afdelingsniveau en hoe CIP programma's deze bijdrage optimaal kunnen faciliteren. Er zijn daartoe 26 semigestructureerde individuele en vier focusgroep interviews afgenomen. Er werd gesproken met CIP uit vijf ziekenhuizen. Uit de thematische analyse kwam naar voren dat CIP voor zichzelf een rol zien in het identificeren van risico's op het gebied van infectiepreventie, het monitoren van de toepassing van infectiepreventiemaatregelen op de eigen afdeling, het informeren van hun collega's over infectiepreventie en het faciliteren van collega's in de toepassing ervan. De ervaringen van CIP varieerden van het zich afvragen hoe ze hun rol moesten oppakken tot het vol zelfvertrouwen nemen van initiatieven en het kunnen beschrijven van de verbeteringen die deze initiatieven opleverden. Tijdens de COVID-19-pandemie voelden CIP zich extra verantwoordelijk in hun rol.

Bij overplaatsing naar een andere afdeling leek de focus op de CIP rol echter meer naar de achtergrond te verdwijnen. In het algemeen voelden CIP zich gesterkt om meer activiteiten te initiëren wanneer zij werden geïnspireerd door andere CIP en wanneer zij werden ondersteund door een deskundige infectiepreventie en het afdelingshoofd. Deze randvoorwaarden maakten de kans groter dat CIP initiatieven namen die bijdroegen aan de toepassing van infectiepreventie op afdelingsniveau. Daarom wordt aanbevolen om te investeren in de empowerment van CIP als een van de pijlers van CIP programma's.

In **hoofdstukken 5 en 6**, het tweede deel van dit proefschrift, worden de resultaten van het CIP programma in een academisch ziekenhuis geëvalueerd.

De effecten van een CIP programma op het naleven van voorschriften over het dragen van sieraden en dienstkleding worden beschreven in **hoofdstuk 5**. In dit single center longitudinale onderzoek is de naleving op acht momenten tussen maart 2014 en juni 2016 gemeten. Er werden in totaal 1920 zorgmedewerkers in dienstkleding in de ziekenhuisgangen geobserveerd. CIP verpleegkundigen werden uitgenodigd om op basis van de uitkomsten van de eerste observaties, oorzaken van (niet) naleven te bespreken en mogelijke oplossingen te prioriteren met hun collega's. Gebrek aan kennis, gebrek aan faciliteiten en een negatieve houding t.o.v. het beleid werden geïdentificeerd als belangrijkste oorzaken van niet-naleving. Op maat gemaakte interventies gericht op deze oorzaken verhoogden de algehele naleving met 39.6% (95% BI 31.7-47.5) van 42.5% naar 65.4%.

In **hoofdstuk 6** wordt de impact van één specifiek CIP programma beschreven. De uitkomsten van dit onderzoek zijn georganiseerd langs de vijf dimensies van het RE-AIM model: Reach, Effectiveness, Adoption, Implementation en Maintenance. Gegevens werden verzameld uit projectdocumenten en met behulp van directe observaties, vragenlijsten en interviews. Tussen 2014 en 2018 nam gemiddeld 91% van de klinische afdelingen en 58% van de poliklinieken deel aan het programma (Reach). Het CIP programma richtte zich onder andere op het verbeteren van de naleving van diverse infectiepreventieprotocollen zoals het dienstkleding en handhygiëne protocol. De naleving van beide protocollen verbeterde. De toepassing van handhygiëne verbeterde van 44.5% (95%BI 42.9-46.0) in 2014 naar 70.9% (95%BI 69.4-72.4) in 2018. CIP voelden zich betrokken en beschouwden hun bijdrage aan deze naleving als cruciaal. Afdelingshoofden bevestigden de waarde van CIP bij het implementeren van infectiepreventie (Effectiviteit). Het programma is zowel op ziekenhuis- als afdelingsniveau ingebed (Adoptie). De opzet van het programma is gebruikt als blauwdruk voor programma's voor andere aandachtsvelden, zoals medicatieveiligheid en valpreventie. In de loop der jaren zijn onderwijs-, trainings- en ondersteuningsstrategieën verfijnd, met meer nadruk op afdelingsspecifieke aspecten (implementatie). Het programma vormt

een belangrijk onderdeel van het infectiepreventiebeleid (Maintenance). Het programma helpt CIP om infectiepreventie te verbeteren, met name op klinische afdelingen. De sleutel tot deze verbeteringen is flexibiliteit van het programma. Het maakt het mogelijk om activiteiten op maat te maken en af te stemmen op de specifieke behoeften van elke afdeling.

Het derde deel van dit proefschrift, **hoofdstukken 7 en 8**, beschrijft een synthese van de resultaten en vat deze resultaten samen.

Deskundigen infectiepreventie worden bij het implementeren van een CIP programma geconfronteerd met verschillende uitdagingen. Het identificeren van strategieën om deze uitdagingen aan te pakken, kan helpen om de impact van huidige programma's te verbeteren en richting te geven aan de toekomstige implementatie ervan. In **hoofdstuk 7** zijn de belangrijkste belemmeringen voor de implementatie van CIP programma geïdentificeerd en samengevat. Een panel van experts koppelde deze belemmeringen, geïdentificeerd in de eerdere studies, aan de meest passende constructen en domeinen van het Consolidated Framework for Implementation Research (CFIR). Het CFIR omvat begrippen vanuit 19 implementatiemodellen en theorieën; het geeft daarmee een uitgebreid overzicht van de belangrijkste theorieën en conceptuele modellen in implementatieonderzoek.

De Expert Recommendations for Implementing Change (ERIC) Implementation Strategy Matching-tool werd vervolgens toegepast om implementatiestrategieën te identificeren die deze belemmeringen zouden kunnen aanpakken. Deze ERIC tool is gebaseerd op het CFIR-raamwerk en combineert constructen met aanbevelingen voor implementatiestrategieën. Barrières werden vooral gevonden binnen de CFIR-domeinen 'inner setting' (de kenmerken van de organisatie) en 'proces' (de stadia van implementatie). Met de ERIC tool zijn de tien belangrijkste strategieën geïdentificeerd om de implementatie van CIP programma's te stimuleren. Deze strategieën waren 1) het voorbereiden en identificeren van individuen die het goede voorbeeld geven) 2) het voeren van discussies over de te nemen maatregelen op instellings- en afdelingsniveau, 3) het identificeren van belemmerende en bevorderende factoren, 4) het informeren van (informele) leiders, 5) het ondersteunen en vergemakkelijken van de CIP rol, 6) het opzetten van een lerende samenwerking, 7) het uitvoeren van een analyse naar lokale behoeften, 8) het ontwikkelen van een formele implementatieblauwdruk, 9) het bouwen aan relaties met individuele collega's en afdelingen, en 10) het identificeren van individuen die het voortouw nemen. Deze bevindingen kunnen helpen bij het plannen van de implementatie van een CIP programma, maar kunnen de analyse van lokale implementatiebehoeften niet vervangen. Met de CFIR-ERIC-tool kunnen strategieën worden afgestemd op de specifieke belemmeringen van elk ziekenhuis.

In **hoofdstuk 8** worden de resultaten van de studies uit dit proefschrift samengevat en in een breder perspectief geplaatst. De bevindingen uit dit proefschrift ondersteunen de investering in CIP en de bijbehorende programma's: CIP vergroten het bewustzijn voor infectiepreventie en hebben de potentie om de toepassing van infectiepreventiemaatregelen in ziekenhuizen te verbeteren. CIP programma's lopen echter sterk uiteen qua inhoud en organisatie. Elementen die de ondersteuning van CIP faciliteren, zijn onder meer een duidelijk rolprofiel, betrokkenheid vanuit het gehele infectiepreventieteam, ondersteuning door ziekenhuis- en afdelingsmanagement, scholing over infectiepreventie in combinatie met training in implementatievaardigheden en contact met andere CIP. Op afdelingsniveau helpen actieplannen bij het structureren van de activiteiten van de CIP. Twee belangrijke strategieën kunnen de implementatie van CIP ondersteunen: 1) de ontwikkeling van onderlinge relaties tussen belanghebbenden om culturele verandering te bevorderen en 2) het gebruik van evaluatieve en iteratieve strategieën om veranderingen duurzaam te realiseren en monitoring van infectiepreventie te borgen.

Toekomstig onderzoek naar CIP en bijpassende programma's zou zich moeten richten op de effectiviteit van CIP programma's. Daarnaast dient onderzoek zich te richten op implementatie van bevindingen uit dit proefschrift in diverse ziekenhuizen, dit kan via participatief actieonderzoek en mensgerichte ontwerptechnieken. Tot slot dient onderzoek zich te richten op het transformeren van CIP programma's in netwerken en op de invloed van kenmerken van verpleegkundigen op het aannemen van de rol van CIP; vanuit de sociale netwerktheorie kan dit onderzocht worden.

Kortom

In twee derde van de Nederlandse ziekenhuizen zijn contactpersonen voor infectiepreventie (CIP) actief: verpleegkundigen met extra aandacht voor infectiepreventie. Goede inzet van deze contactpersonen leidt tot betere naleving van infectiepreventiebeleid en minder kans op zorginfecties. CIP worden bij hun activiteiten in verschillende ziekenhuizen ondersteund door lokaal opgezette programma's. Deze variëren in opzet en inhoud. Door het lokale karakter van programma's wordt de bestaande kennis over CIP programma's niet voldoende benut; niet in ieder ziekenhuis wordt doelbewust gekozen voor de effectieve elementen om zo'n programma te implementeren en te behouden. Daarnaast worden belemmerende en bevorderende factoren niet altijd herkend en daardoor niet effectief geadresseerd. Hierdoor worden wisselende resultaten behaald en kan naleving van infectiepreventiebeleid achterblijven.

Diverse elementen uit deze programma's zijn effectief gebleken, zoals training in implementatie vaardigheden.

Trainingsprogramma's waarin zowel kennis als vaardigheden worden aangeboden worden beter geëvalueerd door deskundigen infectiepreventie dan programma's die zich alleen richten op kennisoverdracht óf programma's waarbij geen gebruik wordt gemaakt van training. Elementen die de ondersteuning van CIP faciliteren zijn onder meer een duidelijk rolprofiel, betrokkenheid vanuit het gehele infectiepreventieteam, ondersteuning door ziekenhuis- en afdelingsmanagement en contact met andere CIP. Op afdelingsniveau helpen actieplannen bij het structureren van de activiteiten van de CIP. Het betrekken van belanghebbenden en het doorlopen van een volledige kwaliteitscyclus zijn belangrijke voorwaarden voor een succesvolle implementatie.

In een reeds gestart vervolgproject implementeren we een CIP programma in diverse Nederlandse ziekenhuizen waarin we samenwerken met verpleegkundigen, deskundigen infectiepreventie, trainers en andere belanghebbenden. Bewezen effectieve elementen, bekende bevorderende factoren en evidence-based implementatiestrategieën worden geïntegreerd in het programma en het implementatietraject. Zo benutten we de kennis over CIP programma's verkregen uit dit proefschrift en stimuleren we de inbedding van deze kennis in de praktijk.

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Dan mijn promotieteam: Prof. Dr. Christina Vandenbroucke-Grauls, Prof. Dr. Martine de Bruijne, Dr. Rosa van Mansfeld en Dr. Irene Jongerden.

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Collega's van de afdeling infectiepreventie, Amsterdam UMC. Onderzoek opzetten en uitvoeren, samen leren van de uitkomsten en deze kennis toepassen in ons eigen ziekenhuis is een prachtige manier van samenwerken. Het is, voor mij, de essentie van evidence-based practice en passend bij onze academische werkeenheid. Wat zijn wij een fijn team, ieder met zijn eigen kwaliteiten.

Sjoukje, in 2009 was ik als CIP aanwezig bij de eerste bijeenkomst die jij, als deskundige infectiepreventie in opleiding, in het toenmalige Medisch Centrum Alkmaar leidde. Wie had kunnen bedenken dat je me in de jaren daarna, samen met Marijke, zou opleiden tot deskundige infectiepreventie. Dank je wel voor het delen van jouw kennis en heldere visie op infectiepreventie. Samen naar de SHEA spring conference in 2015 was fantastisch. Ik hoop dat we nog veel congressen samen zullen bezoeken.

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ABOUT THE AUTHOR

Mireille Dekker (1973) studied Nursing at the University of Applied Sciences in Alkmaar and received her bachelor's degree in 1994. After graduating she worked as a registered nurse in various health care settings. She specialized in Obstetrics and was appointed as an infection control link nurse for the obstetrics ward at the Medisch Centrum Alkmaar. This resulted in a second specialization in infection control which she completed at the Wenckebach Institute in 2013.

Thereafter, she started working at the department of Medical Microbiology and Infection Prevention of Amsterdam UMC and contributed to several projects to promote infection control for the Commission on Infection Control and Antibiotics, founded by prof. dr. Christina Vandenbroucke and prof. dr. Michiel van Agtmael. She developed and coordinated the VUmc infection control link nurse network which received the VUmc profile price of 2016. A price which is awarded annually to multi-disciplinary teams that have delivered exceptional multi-year performances on one or more core tasks within VUmc.

In 2017 Mireille received a Master's degree in clinical epidemiology. Her master thesis served as a prelude to her PhD trajectory. She combined her work as an infection control practitioner and as the coordinator of the link nurse program with her research activities. As a PhD student she was a member of the research group Quality and Safety of Healthcare, led by prof. dr. Martine de Bruijne and prof. dr. Cordula Wagner.

Mireille received funding from the Amsterdam Public Health research institute to continue her research regarding the development and implementation of infection control link nurse programs as a postdoctoral fellow.