Isolation Precautions Use for Multidrug-Resistant Organism Infection in Nursing Homes:

Evidence for Decision-Making

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ABSTRACT

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Over the past decade, efforts led by the U.S. Department of Health and Human Services (HHS) have reduced healthcare-associated infections in acute care settings nationally.[34] In 2013, HHS identified that the next phase of these healthcare-associated infection reduction initiatives would target long-term care facilities through the publication of a new chapter in the *National Action Plan to Prevent Health Care Associated Infections* devoted to this setting.[168] Long-term care facilities are nursing facilities that provide "medical, skilled nursing and rehabilitative services on an inpatient basis to individuals who need assistance preforming activities of daily living, such as bathing and dressing".[161] These facilities are the primary residence for 2.5 million, predominantly elderly Americans[157] and represented $143 billion nationally in healthcare costs as of 2010.[161] Accordingly, it is a national priority to reduce healthcare-associated infections in this setting and protect this vulnerable population.

Healthcare-associated infections caused by multidrug-resistant organisms (MDROs) are a particular burden in the long-term care population.[150] These pathogens, usually bacteria, are defined as being resistant to one or more classes of antimicrobial agents. However, MDROs frequently exhibit resistance to nearly all antimicrobial drugs.[148] Clinical infection control guidelines recommend isolation precautions to prevent MDRO transmission, based on evidence collected in acute care settings.[111] However, the limited evidence that is available from studies in long-term care facilities suggests that isolation precautions may not be effective in this setting.[164] Given that the reduction of antibiotic resistant infections is a priority of the HHS,[168] The White House,[122] Healthy People 2020,[78] and the World Health Organization,[175] it is necessary to confirm and support the appropriate use of isolation precautions for MDROs with evidence specific to long-term care facilities.

Therefore, this dissertation describes the current evidence for and use of isolation precautions in long-term care facilities for MDROs. Further, it offers the most comprehensive descriptions of both isolation precautions use and predictors of MDRO infection in nursing homes (NHs), a specific type of long-term care residential setting. To assist the reader, **Chapter 1** will provide background for these

studies including context for current infection control and prevention practices in long-term care facilities, the importance of MDRO infections and the need for new evidence regarding isolation precautions in long-term care. It will also discuss the aims and significance of this dissertation in context of a conceptual framework, gaps in the literature and potential to improve clinical practice. Next, **Chapters 2 and 3 of** this dissertation systematically review the current evidence regarding effectiveness of isolation precautions against MDROs and the cost of infection prevention and control in this setting, respectively. These chapters outline how publications focused on long-term care are lacking in quality and quantity and offer suggestions for improvement in future research. **Chapter 4** qualitatively describes decision-making process regarding use of isolation-based infection prevention techniques in NHs, which depends on four key considerations: perceived risk of transmission, conflict with quality of life goals, resource availability and lack of understanding. **Chapter 5** builds on this qualitative analysis by quantitatively examining predictors of isolation precautions use for MDRO infection in a large, national dataset. This analysis confirms that isolation is rarely used and there is variation across NHs' practice. However, NH staff may be tailoring infection prevention and control practice to the needs of specific residents, as would be expected based on the results of the qualitative analysis. **Chapter 6** presents an analysis of MDRO infection predictors among elderly NH residents across the U.S. This study confirms concepts associated with MDRO infection in previous studies (e.g., low functionality) and provides more specificity in operationalization of these concepts than has been previously determined (e.g., needing support with locomotion), which can inform future use of isolation precautions in NHs. Finally, **Chapter 7** contains a synthesis and discussion of these findings, as well as recommendations for health policy and future research regarding contact isolation precautions against MDROs in NHs.

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List of Acronyms

Acronym	Full name
AHRF	Area Health Resource File
ARF	Area Resource File, now called Area Health Resource File
AMDA	American Medical Director's Association
CASPER	Certification and Survey Provider Enhanced Reporting
CDC	The Centers for Disease Control and Prevention
CHEERS	Consolidated Health Economic Evaluation Reporting Standards
CI	Confidence interval
CINAHL	EBSCO Cumulative Index of Nursing and Allied Health Literature
CMS	Centers for Medicare and Medicaid Services
CRKP	Carbapenem-resistant *Klebsiella pneumonia*
FTE	Full time equivalents
EBSL	Extended spectrum beta-lactamase
ED	Emergency department
HAI	Healthcare-associated infections
HHS	U.S. Department of Health and Human Services
ICU	Intensive Care Unit
LTC	Long-term care
LTCFs	Long-term care facilities
MDRO	Multidrug-resistant organism
MDS	Minimum Data Set
MeSH	Medical Subject Headings
MRSA	Methicillin-resistant *Staphylococcus aureus*
MSSA	Methicillin-susceptible *Staphylococcus aureus*
NH	Nursing home
OR	Odds ratio
OSCAR	Online Survey, Certification and Reporting, now called Certification and Survey Provider Enhanced Reporting (CASPER)
PPE	Personal protective equipment
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
QALY	Quality-adjusted life years
QHES	Quality of Health Economic Studies instrument
R-GNB	Antibiotic-resistant gram-negative bacteria
RCT	Randomized controlled trials
RN	Registered nurse
RR	Risk ratio
SARS	Severe Acute Respiratory Syndrome
SD	Standard deviation
SE	Standard error
Tb	Tuberculosis
U.S.	United States
USD	United States dollars
UTI	Urinary tract infection
VA	Veteran's Administration
VRE	Vancomycin-resistant enterococcus
WHO	World Health Organization

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Chapter 1: Introduction

The following chapter introduces the problem of infection prevention and control in long-term care facilities. More specifically, it outlines the challenges due to multidrug-resistant organism (MDRO) infections in this setting and provides an overview of isolation precautions, which are part of the current standard of care to control and prevent MDRO transmission. This chapter also addresses the challenges of infection prevention and control unique to the long-term care setting, particularly preventing MDRO infection in nursing homes (NHs). After these topics are discussed in the context of the most recent scientific literature, gaps in existing knowledge are identified. The chapter concludes with a description of the conceptual framework used to guide analysis of these topics, the specific aims of this dissertation, and potential contributions of the findings to inform NH practice and policy.

Long-term Care Facilities

Long-term care is a unique but important niche within U.S. healthcare. Long-term care, which includes both chronic and short-term rehabilitation services[150] for those who cannot function independently in the community,[161] may be provided in a person's home, other community setting, assisted living residence, or nursing facility.[3] The focus of this dissertation is institutional long-term care facilities, specifically NHs[168] and those who reside in this setting, commonly referred to as "residents" rather than "patients".[6]

While long-term care facilities may provide chronic or short term care for those who are unable to manage themselves independently, NHs are defined as facilities licensed to provide care with an organized professional staff and inpatient beds that provide continuous nursing care to residents not in an acute phase of illness.[150] Other types of long-term care facilities are often referred to interchangeably, but are not synonymous. For example, board and care and assisted living facilities may provide assistance with activities of daily living (such as bathing and dressing) but may or may not provide assistance with medications or other nursing care services as are received in NHs.[42] Skilled nursing facilities are certified and reimbursed by Medicare for short-term care (through 100 days[138]). In contrast, NHs are certified by Medicaid and are primarily reimbursed by Medicaid, private funds and/or long-term care insurance.[36] Of note, many nursing facilities are certified to accept both Medicare and Medicaid (i.e., to act as both a NH and skilled nursing facility), in which case they are referred to as NHs.[161]

NHs are an important care setting within U.S. healthcare. Of the 2.5 million individuals that currently reside in long-term care facilities, 1.5 million of these individuals are in a NH.[168] NHs also represent the majority of long-term care facilities in the U.S.[149; 157] NHs therefore frequently represent long-term care facilities as a whole[149] and are therefore a primary focus of this work.

Long-term care facilities differ from other healthcare settings in resident population, care goals, and facility resources. The sub-acute population in long-term care facilities is heterogeneous and increasingly complex.[150] In NHs, 90% are considered to be "frail elderly",[157] with 45% of residents being the "oldest old", i.e., over 85 years old.[126] Second, this setting differs from hospitals as NHs are also a primary residence. Therefore, goals of care include resident autonomy, function, dignity, and comfort,[171] in addition to prevention and treatment of illness. Third, these facilities have fewer resources available

than acute care facilities, such as laboratory and imaging services.[111] Due to these attributes, clinical care guidelines recognize that care processes developed in acute care often need to be adapted to the NH setting to consider the needs of the individual resident and specific facility.[6]

NHs have various population demographics, case mix, resources, size, and staff skill mix and staff to resident ratios that are increasingly diverse. One of the ways in which NH diversity has increased is that some NHs have become increasingly specialized for a particular long-term care population (e.g., dementia). Nurse staff to resident ratios is another way in which NHs have become more diverse. While the proportion of NHs with recommended nurse staffing ratios has increased over the past decade, so too has the proportion of NHs failing to meet the minimum staffing ratio requirements.[117] Further, the acuity of illness among NH residents has increased in past decades, but is not consistent between NHs.[150] As a result of the differences between NHs, not only is it a challenge to meet the diverse care needs of this population, it is difficult to measure and ensure care quality across facilities.[117] Therefore, maintaining and improving care quality in this setting remains a major challenge.

Demand for long-term care services will increase. It is anticipated that 70% of individuals who live to age 65 will need a form of long-term care,[167] and the proportion of the U.S. population over the age of 65 is expected to rise from 13% in 2010 to 20% by 2040.[3] The population of NH residents alone is expected to grow from 1.5 million today[168] to 5.3 million by 2030.[157] Moreover, the proportion that is the "oldest old" will also increase as the U.S. population ages. This population requires more intense care and is the fastest growing segment of the U.S. population.[126] Therefore, it is critical to understand the needs of this group to anticipate future care challenges.[126]

The Centers for Medicare and Medicaid Services monitor long-term care facilities through annual inspection surveys. These surveys also determine Medicare and/or Medicaid certification and reimbursement eligibility. Among U.S. NHs, 96% are subject to these inspections.[27] These facilities must also complete the Minimum Data Set (MDS, see Appendix A), which includes extensive clinical assessment information on each resident at regular intervals no less than once every three months (1 quarter). Long-term care facilities that fail to comply with Centers for Medicare and Medicaid Services regulations are issued a deficiency citation (F-tag) that, depending on scope and severity of the infraction, can result in monetary penalty, additional oversight and certification revocation.[41] Despite this regulatory

oversight, 38.5% of NHs receive at least one infection control-related citation annually,[176] which indicates a clear need for care improvement.

Infection Prevention and Control in Long-Term Care Facilities

Burden of Infections in Long-Term Care Facilities

Infections are a leading cause of morbidity and mortality and the primary cause of hospitalizations among long-term care residents.[168] In NHs, an estimated 1.6 to 3.8 million healthcare associated infections (HAIs) occur each year[134] and contribute to 380,000 deaths annually.[33] Those who do not succumb to HAIs are subject to greater functional decline than those who have not had an infection.[22] Further, the prevalence of urinary tract infections, pneumonia, antibiotic-resistant organism infections, wound infection, viral hepatitis and septicemia increased between 2006-2010.[79]

HAIs also pose a significant financial burden to facilities and payers. Annual cost estimates due to HAIs in NHs alone range from $38-137 million in antibiotic therapy and $673 million to $2 billion in hospitalizations.[11; 82] However, the figures presented here represent data that is 15-25 years old and likely underestimate current expenses given increases in healthcare costs over this time.

Challenges to Infection Prevention in Long-Term Care Facilities

Long-term care settings have greater infection prevention and control challenges than in acute care.[168] The vulnerability of the long-term care resident population is one such challenge. Firstly, frail, elderly residents are at particularly high risk for infection[168] due to their aging immune systems, high rates of chronic disability, comorbid conditions, and indwelling devices.[26] Secondly, residents are frequently transferred to and transitioned between multiple healthcare facilities, increasing the likelihood that residents will be exposed to potentially dangerous pathogens from fellow NH residents, even if they are not transferred to another healthcare facility.[26] Thirdly, infection diagnoses may be difficult among elderly residents, especially those unable to make themselves understood. Elderly individuals may not exhibit fever or symptoms characteristic of an infection in younger individuals. Instead, non-specific symptoms and signs may occur, such as increased confusion.[6] Fourthly, as these facilities are both a home and a medical facility,[26] activities to improve quality of life, mobility and socialization inherently increase interpersonal contact and infection risk.[65] Mobile residents, especially those with cognitive impairment, may readily spread pathogens in shared spaces,[150] such as cafeterias, recreation areas and physical

therapy rooms. Especially in NHs, where length of stay lasts months or years, the tradeoff between social contact/resident autonomy and infection control often presents an ethical dilemma.[156]

Demographic trends indicate that existing challenges to infection prevention and control practices in this setting are likely to increase in the future, as the prevalence of infection is anticipated to grow. As discussed above, there will be increased demand for long-term care services as the number of elderly individuals in the U.S. continues to rise.[126] Meeting this demand may strain long-term care facilities' ability to provide consistent, high-quality infection prevention and control practices. Compared with two decades ago, the average NH resident today is older, with higher case acuity and complexity,[117] and is thereby more vulnerable to infection.[149] The infection risk and care demands of each individual resident are likely to continue to increase. Therefore, it is critical to understand and address challenges to care in this setting and needs of residents to maintain and improve care.[126]

Drug-Resistant Organisms in Long-Term Care Facilities

A particular challenge to maintaining the health of this vulnerable population is antimicrobial resistance. Researchers using MDS data from five states found that 12.7 antibiotic-resistant infections per 1000 NH residents occurred in 2003.[136] Antibiotic-resistant infections are a problem among NH residents for most of the same reasons that these residents are at high risk for any infection: frequent transfers between healthcare facilities,[26] common use of indwelling devices,[136] and living in a shared environment.[6] An increasing number of antibiotic-resistant infections are caused by MDROs, such as Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE). The Centers for Disease Control and Prevention (CDC) consider MDROs to be "serious threats"[32] and are of particular concern.[150] Although not fully understood, morbidity and mortality attributable to MDRO infection among NH residents is greater than in MDRO cases in other settings.[150] The longer average length of stay than in hospitals prolongs MDRO exposure and therefore increases transmission risk between residents.[12] Eliminating an MDRO from a long-term care facility is difficult once endemic.[150]

Of note, MDROs may present as either active infection or colonization. The CDC defines infection as the transmission, invasion, and proliferation of a microorganism into a host (i.e., resident) tissue that overcomes the host's defenses and causes a clinical or subclinical host response.[149] Conversely, colonization is the "proliferation of microorganisms on or within body sites without detectable host immune

response, cellular damage, or clinical expression."[149] Persistence of colonization, also termed "carriage", varies and may result in transmission to other individuals. Transmission risk is higher in NHs than in acute care as MDRO-colonized residents returning from a hospital enter this smaller population and thereby increase colonization pressure, i.e., the likelihood of exposure within a specific environment.[12] Therefore, both infection and colonization present a threat to other individuals, though colonization is less readily detected.

Antibiotic resistance in this setting is exacerbated by empirical use of antibiotics, which is widespread due to the high rate of infections[133] and lack of laboratory services.[111] An estimated 25-75% of antibiotic prescriptions in NHs are inappropriate with regard to either the antibiotic type, need, dosing or duration.[133] Poor antimicrobial stewardship contributes to high prevalence of antimicrobial-resistant organisms,[168] and increases individual resident susceptibility to resistant infections[149] as well as other complications that can be lethal and costly.[65] Empirical antibiotic use also increases the probability that resistance will develop in the initial infection.[168] When resistance develops, it can double the cost of treatment.[26]

Given the challenges of controlling MDRO,[148] it is known that some NHs refuse care to MDRO infected or colonized individuals. In one study, approximately 7% of NHs refused to accept new residents known to have MRSA and 17% refused to accept those with VRE.[90] Another survey determined that the rejection rate for MRSA carriers is 28% versus 18% for non-carriers among NHs where beds were available and that placement denial was associated with MDRO carriage after adjustment for other clinical characteristics (odds ratio: 2.7, $p = .02$).[132] Although this practice persists in a minority of NHs,[176] denying entry to a resident with MDRO infection or colonization has been deemed inappropriate practice.[6]

MDRO prevalence appears to be increasing in NHs. A retrospective, longitudinal study using MDS data found that antibiotic-resistant infections increased 17.8% from 2006-2010.[79] Given the demographic shifts that will likely result in a larger, older and frailer resident population discussed above, it is reasonable to expect that prevalence will continue to rise in the absence of an intervention. Given NH residents' vulnerability to infection,[26] the difficulty of treatment, and the residential nature of their environment, preventing MDRO transmission is of paramount importance.[148]

It is possible that infection prevention and control practices might be improved to reduce MDRO colonization and infection. Not only are the majority of HAIs thought to be preventable,[169] it has been suggested that use of certain practices and/or non-compliance with effective practices may be contributing to the high infection rates in this setting.[114] Further, it is known that there are variations in the infection prevention and control practices used in long-term care. Use of various infection control practices may be attributed to variation among facilities and the populations they serve (e.g., resident acuity, facility resources,[117] and state policies[51]), which may be unavoidable. However, these factors affect care quality and resident satisfaction.[117] More detailed information regarding the differences in state Department of Health activities and policies that may influence infections in NHs is available in Additional Appendix A: State Focus on Health Care-Associated Infection Prevention in Nursing Homes.

Isolation Precautions

Isolation precautions are a widely-recommended technique to control transmission of MDROs as well as other pathogens with high morbidity, mortality, or epidemiological significance.[99; 130; 148; 149; 150; 158] Isolation precautions are a bundle of activities used in healthcare care settings to reduce potential transmission of infectious pathogens between persons and between persons and their environment(s). These include the "routine use of hand hygiene, gloves, gowns, masks and eye protection depending on anticipated exposures", which are called "standard precautions". Standard precautions are considered to be the minimum infection prevention practices to protect both patients (long-term care residents) and healthcare workers from transmission[150] (see Table 1.1). In addition to standard precautions, isolation precautions include "transmission-based precautions", which involve the physical isolation of individuals infected or suspected to be infected from others not affected by the disease[93] and other transmission prevention activities that depend on the specific or suspected infectious agent as well as epidemiological context (e.g., an outbreak scenario).[6] The three types of transmission-based precautions, contact, droplet and airborne, are described below (see Table 1.1).

Table 1.1 Standard and transmission-based precautions
(As described by the CDC clinical guidelines for isolation precautions[149])

Precaution Type	Infection Indication	Organism Example	Activities
Standard	• All patients, all times, regardless of infectious status*	--	• Hand hygiene • Use of gloves, gown, mask, eye protection, or face shield, depending on the anticipated exposure • Safe injection practices • Respiratory hygiene/cough etiquette • Use of masks for insertion of catheters or injection of material into spinal or epidural spaces via lumbar puncture procedures
Transmission-Based			
Contact	• Infectious pathogens spread by direct or indirect contact with the patient* or the patient's* environment, especially microorganisms of epidemiological significance • Also draining wounds or other uncontrolled bodily secretion(s)	Methicillin-resistant *Staphylococcus aureus*	• Standard precautions • Private room (if available) or IP risk assessment and ≥3ft between beds • Healthcare personnel wear gown and gloves "for all interactions that may involve contact with the patient* or potentially contaminated areas in the patient's* environment" p. 70, donned at room entry
Droplet	• Infectious pathogens transmitted "through close respiratory or mucous membrane contact with respiratory secretions" p. 70	Influenza virus	• Standard precautions • Private room (if available) or IP risk assessment and ≥3ft between beds with curtains drawn in between • Healthcare personnel wear gown, gloves and mask for "close contact with infectious patients,"* donned at room entry
Airborne	• Infectious pathogens that are "infectious over long distances when suspended in the air" p. 71	Tuberculosis	• Standard precautions • Placement in private airborne infection isolation room (AIIR), a room that is equipped with special air handling and ventilation capacity that meet the American Institute of Architects/Facility Guidelines Institute (AIA/FGI) standards for AIIRs • Healthcare personnel wear mask or respirator, depending on the disease-specific recommendations, donned at room entry

Note: *Individuals admitted to an acute care setting, referred to as "residents" if admitted to the long-term care setting. CDC = Centers for Disease Control and Prevention, IP = infection preventionist.

Transmission-Based Precautions

Contact precautions are indicated for pathogens transmitted by direct and indirect contact (i.e., contact with contaminated individuals and fomites, respectively), such as MDROs. These practices should also be used when a patient/resident has “excessive” wound drainage, fecal incontinence, or other bodily discharges that increase risk of transmission to others.[149] To comply with contact precautions, healthcare workers must wear a gown and gloves upon entry to a patient’s (or resident’s) room, and remove this personal protective equipment prior to exiting the room.[149]

Droplet isolation is used for pathogens that can be carried in droplets through the air over short distances (≤ 3ft) and enter through droplet contact with a mucous membrane (i.e., nose, mouth, eyes). Therefore, droplet precautions include standard precautions and placement in a private room, if possible. In semi-private rooms, beds should be placed >3ft apart and the curtains should be drawn around the infected resident’s bed. Droplet precautions require healthcare workers to wear a mask upon close contact with the infected individual, beginning with entry to the room.

Airborne precautions are used for pathogens that are airborne over greater distances than droplet transmission. Healthcare workers are required to wear a mask or respirator in the patient’s (or resident’s) room consistent with disease specific recommendations.[149] Further, airborne precautions include placement in a private room equipped with a ventilation system (e.g., negative pressure) specified by American Institute of Architects/Facility Guidelines Institute. Of note, long-term care facilities may not have airborne infectious isolation capabilities. These facilities must transfer residents who need airborne isolation precautions to another healthcare facility with that capacity.[6]

Contact precautions represent most of isolation use in hospitals (84% vs. 14% droplet and 2% airborne),[172] as direct and indirect contact is the most common mode of pathogen transmission. When diseases can be spread by multiple, or uncertain routes, multiple types of transmission precautions are to be used simultaneously. For example, varicella zoster virus (shingles) requires both airborne and contact precautions.[149] Although it appears that droplet or airborne transmission of MDRO is possible,[61] direct and indirect contact are the primary mode by which MDROs are transmitted.[149] The CDC, the World Health Organization, Society for Healthcare Epidemiology of America and Association for Professionals in Infection Control recommend contact isolation precautions to prevent MDRO transmission.[130; 148; 150]

Some clinical guidelines mention additional activities to prevent disease transmission as part of isolation precautions.[9; 54; 130] These include having dedicated, non-critical care equipment for the isolated individual,[10] for example, a private commode for diarrheal disease.[54] Some isolation precautions descriptions also include environmental and care equipment cleaning, linen laundering procedures and respiratory etiquette.[10] A gown and gloves must be used outside of the patient/resident's room when that individual must be moved,[10] although transportation should be avoided, if possible.[130] The Association for Professionals in Infection Control and Epidemiology's 2010 guidelines for MDRO infection prevention state that some institutions require masks as part of contact isolation for MRSA cases, though this remains controversial.[10]

Cohorting as a Transmission-Based Precautions Alternative

A related but different concept to isolation precautions is cohorting. Cohorting is "the practice of grouping together patients who are colonized or infected with the same organism to confine their care to one area and prevent contact with other patients" [149] Similarly to isolation precautions, the goal of cohorting is to prevent contact between susceptible and infected/colonized individuals [130] As mentioned above, isolation precautions involve segregation of individuals rather than grouping infected individuals by disease type. Cohorting is recommended when a private room is not available (e.g., during an outbreak scenario).[149]

Isolation Precautions Use

Isolation precautions (as well as cohorting) use depends on facility resources, policies and staff judgment. As mentioned above, when a private room is unavailable, an infection preventionist should assess risk of transmission.[149] One of the considerations suggested by the current clinical guidelines is whether secretions are contained within a device (i.e., urinary catheter drainage bag) or can be covered under a dressing.[6] Further, it is accepted that not all individuals colonized with an MDRO but without an active MDRO infection may be isolated.[6]

The process by which isolation precautions are implemented and discontinued differs by organism[149] and may differ by facility. Some healthcare facilities only implement isolation after confirming that a resistant infection exists through a positive culture potentially exposing healthcare workers, if not other patients/residents or visitors to the infectious pathogen. Some facilities will remove isolation only

after one or multiple negative cultures.[10] However, it is not clear from the scientific literature when it is best to implement and discontinue isolation precautions. The Infectious Disease Society of America recommends discontinuing isolation for *Clostridium difficile* with resolution of symptoms[54] but this recommendation may not be useful for facilities in which colonized individuals (i.e., without active infection) are isolated. Therefore, individual healthcare institutions determine how long the precautions should remain in effect.[10]

Benefits and Drawbacks of Isolation Precautions

Isolating those with communicable pathogen(s) has been a key means to control disease since the black plague outbreak of the 14th century,[93] but rationale for isolation use has traditionally been theoretical rather than empirical.[93] In theory, benefits of isolation precautions include prevention of pathogen transmission to susceptible patients (or residents) and healthcare workers.[142] However, scientific evidence regarding the effectiveness of isolation precautions is mixed.[2; 18; 55; 59; 91] A recent review identified that contact isolation precautions are effective against MRSA transmission, but only during outbreaks and/or periods of high compliance.[91] Another review and meta-analysis showed no effect of contact isolation against VRE transmission.[59] A third recent review concluded that contact isolation precautions have uncertain effectiveness against VRE and MRSA infections.[119]

While numerous methodological challenges to studying isolation precaution effectiveness have been noted in the literature,[93] it is possible that conflicting findings may be due to the diversity of settings in which these studies were conducted. Recent studies have taken place in many different countries including France,[73] Great Britain,[43] Hong Kong,[44] Israel,[53] Taiwan,[98] and the United States.[14; 15] Clinical guidelines that address isolation precautions in these countries vary, even among those from English-speaking countries.[2] Moreover, variation in the healthcare systems where these studies were performed limits external validity of the study results[178] and obfuscates how these results should be interpreted.

On the other hand, the negative consequences of isolation precautions to healthcare facilities, patients, and long-term care residents have been well documented.[77] For healthcare facilities, including NHs, isolation consumes a high and unpredictable volume of resources.[2; 65] For acute care patients, confinement to a solitary room is associated with functional decline[111] and increased anxiety and depression.[30] Among surgical patients, it has been demonstrated that those who are isolated receive half

as many visits from healthcare professionals[68] and fewer vital sign measurements compared with those not on isolation precautions.[111] This may contribute to the association between isolation precautions use and more adverse events and medical errors suffered by those who are isolated.[118]

Isolation Precautions in Long-term Care

Like other recommendations for infection prevention and control, data supporting the recommendations for isolation precautions use was collected in acute care settings[111; 149] and may not apply to the long-term care setting. First, implementing these resource-intensive practices is more difficult in NHs where resources are more constrained than in acute care (e.g., less private rooms).[111] Second, the negative consequences of isolation directly conflict with NH residential goals of care (which include promoting group activities, socialization, mobility, activities of daily living[65] and resident comfort[150]). It is also possible that the functional decline[111] and negative psychological consequences[118] associated with isolation precautions in acute care are worse in NHs as this is a home to many residents, as well as a healthcare facility.[72] Hence, use of isolation precautions has ethical implications in the long-term care setting where staff need to balance avoiding social stigma of the infected resident[112] and reducing risk of transmission to the surrounding residents.

Replicating acute care interventions may be ineffective as well as impractical in NHs.[111] An evaluation of contact precautions in NHs showed no difference in VRE transmission rates between contact precautions use and use of gloves with all resident contact.[164] Another study showed similar MRSA incidence in NH facilities that use and do not use isolation precautions for MRSA.[96] The two studies that produced these data were each restricted to a single facility and thereby have limited external validity given the high variation in NH facility and resident characteristics.[117] As such, effectiveness of isolation precautions has not been substantiated in long-term care.[19]

Recognizing that long-term care facilities have different populations and needs, modified isolation precautions as well as alternative practices appear to be in use. For example, the incidence of a specific pathogen in a long-term care facility and perceived risk to other residents determines if isolation precautions are to be used.[10] Further, the CDC and the American Medical Directors Association emphasize that clinical guidelines should be adapted to the needs of the individual resident.[6; 149] Consequently, 85-90% of NHs allow select MDRO-infected residents to leave their rooms if they are

deemed capable of adequate hand washing, containing bodily fluids, and covering infected wounds.[90; 125] In a previous survey of 331 NHs in Iowa, most facilities reported use of isolation precautions for MRSA or VRE infections. The majority also reported cohorting some residents infected with these organisms. Staff in approximately one-third of the NHs reported that the need for private room placement depended on the particular resident. However, the survey did not capture how it was determined that isolation, cohorting or some other isolation-based infection control practice was appropriate.[90]

Gaps in Existing Literature

Key information that NH staff may use to make decisions regarding infection prevention and control practices is not well-established in the literature, especially around which residents to isolate. This information includes the effectiveness of isolation precautions for MDRO, costs of isolation and other infection control and prevention practices in long-term care, and how isolation precautions and other isolation-based practices are currently used in NHs. Finally, better information about MDRO transmission risk to specific individuals is needed help NH staff to tailor practice to the needs of the individual resident, NH population and facility.

Effectiveness evidence for isolation precautions use in long-term care is insufficient. One study evaluating the effectiveness of isolation precautions in this setting included data from a single long-term care facility,[164] limiting the study's external validity. While many more studies have been conducted in acute care settings, these had mixed results regarding isolation precautions effectiveness against MDRO.[2; 18; 55; 59] Publications addressing this subject generally evaluated effectiveness for MRSA or VRE, not emerging MDROs (e.g., *Acinetobacter baumannii*). Further, reviews of these publications often group isolation precautions with other infection control practices such as active surveillance.[2; 18; 55; 59; 121] An updated review and synthesis of evidence specific to isolation precautions effectiveness, including emerging MDRO outcomes may be beneficial to NH staff.[7; 165]

Determining the costs of isolation precautions as well as other infection prevention activities in long-term care facilities may also be an important consideration for providers in this setting. Although some studies have examined the financial burden HAI,[26; 85] cost estimates of infection prevention practices in long-term care facilities have not been determined. Understanding the costs of various

infection prevention and control activities would be useful to weigh the relative benefits and drawbacks of these care processes.[120]

To generate new evidence to support decision-making around whether to use isolation precautions, it is important to first understand the decision-making process concerning isolation in NHs and how isolation precautions are currently in use. Existing evidence indicates that long-term care facility staff consider various isolation-based practices to contain infections.[90] However, a gap in the literature exists regarding the thought processes, perceptions and considerations of NH staff when making these decisions.

Equally important to how NH staff perceive they use isolation is how isolation precautions are actually used in long-term care facilities across the nation. Because the most recent version of the MDS (version 3.0, starting in October 2010) initiated data collection on the use of isolation precautions, there is now an opportunity to examine the predictors of isolation precautions, including a broad range of potential predictors for the first time at a national level.

The MDS 3.0 also provides the opportunity to investigate MDRO risk among NH residents across the nation, which can address a gap in the literature. Table 1.2 shows the results of a search of peer-reviewed, published literature regarding risk factors for MDRO transmission, infection or colonization among long-term care facility residents. Most of these studies were restricted to a few facilities and/or specific geographies,[90; 108; 113; 125; 136] including studies conducted in Poland[137] and Australia.[97] Given the high heterogeneity and specialization across NHs,[117; 150] the external validity of these studies is limited, leaving a gap in the evidence specific to this setting. Rogers et al. examined prevalence and select resident risk factors of antibiotic-resistant infection in NHs across 5 states.[136] However, these data are a decade old and, as mentioned above, infections in NHs have been rising since this study was conducted.[79] More recently, investigators used 2010 and 2011 MDS assessments to characterize NH residents with MDRO infection, but did not perform any statistical analyses to compare the characteristics of MDRO-infected and non-MDRO infected individuals.[87] Updated evidence with high external validity is needed regarding risk of MDRO among the NH population.

Table 1.2 Risk factors for antibiotic-resistant organism colonization or infection among long-term care facility residents.

Concept	Assoc.	Study Details
Low Activities of Daily Living (ADLs) Abilities	-	• Paraplegia and semi-paraplegia (lower ADLs) associated with antibiotic-resistant infection in NH residents[136] • Walking, feeding or toileting disability (lower ADLs) associated with shorter time to R-GNB acquisition in NH residents[108] • Walking disability (lower ADLs) associated with shorter time to VRE acquisition in NH residents[108] • Lower NH resident functionality is associated with colonization with multidrug-resistant *Acinetobacter baumanni*i[113] • Limited physical activity (ADLs) associated with MRSA incidence among LTCF residents[137]
Admitting Facility	+	• NH residents admitted from rehabilitation hospitals had greatest risk for antibiotic-resistant infection[136]
Age	-	• Lower age associated with antibiotic-resistant infection in NH residents[136] • Lower age associated with greater time to MDRO infection among NH residents[108]
Antibacterial Soap Use	-	• Antibacterial soap use negatively associated with MRSA among NH residents[101]
Antibiotic Exposure	+	• Antibiotic exposure in past 30 days associated with less time to VRE infection among NH residents [108] • Antimicrobial treatment in preceding 6 months associated with VRE colonization among LTCF residents[125] • Systemic antibiotic use for >14 days associated with MRSA colonization among LTCF residents [97] • Fluoroquinolone use associated with R-GNB colonization among LTCF residents[97] • Systemic antimicrobial use in past 6 months associated with MRSA acquisition in LTCF residents[154] • TMP/SMX and fluoroquinolone use associated with TMP/SMX-resistant Enterobacteriaceae and fluoroquinolone-resistant Enterobacteriaceae risk among NH residents[101]
Colonization Pressure	+	• The proportion of individuals in LTCFs with MRSA increases transmission risk to residents not previously colonized residents[12]
Colonization with another MDRO	+	• NH residents with urinary catheter and/or feeding tube colonized with multidrug resistant *Acinetobacter baumannii* are more likely to be colonized with another MDRO[113]
Dementia	+	• Advanced dementia associated with MRSA colonization among LTCF residents[97]
Diabetes Mellitus	+	• LTCF residents infected with MRSA were more likely to have diabetes compared to those with MSSA infection[25] • Diabetic NH residents with urinary catheter and/or feeding tube, more likely to become colonized with multidrug resistant *Acinetobacter baumannii*[113] • Antibiotic-resistant infection incidence in NHs associated with diabetes[136]
Dialysis	+	• Antibiotic-resistant infection incidence associated with dialysis[136]
Facility Size	+	• Larger facilities more likely to have cared for residents known to have VRE or MRSA[90]
Gender (female)	-	• Males at higher risk for antibiotic-resistant infection among NH residents[136]
Hospitalization	+	• Hospitalization in past 3 days associated with R-GNB, VRE and MRSA acquisition[108] • VRE colonization associated with hospitalization in preceding 6 months among LTCF residents[125]

Concept	Assoc.	Study Details
Incontinence	+	• Stool incontinence associated with MRSA incidence among LTCF residents[137]
Indwelling Devices	+	• LTCF residents infected with MRSA were more likely to have a urinary tract and intravenous catheter, nasogastric tube, or tracheostomy tube compared to those with MSSA infection[25] • Most common site for MRSA is an indwelling catheter[90] • Tracheostomy, feeding tubes, and urinary catheterization associated with antibiotic-resistant infection among NH residents[136] • Medical device in situ associated with MDRO colonization[97] • Urinary catheters associated with MRSA incidence among LTCF residents[137]
Intravenous Medications	+	• Use of intravenous medications associated with antibiotic-resistant infection among NH residents[136]
Nursing Resource Utilization	+	• Overall need for nursing according to Arling score associated with earlier MRSA and VRE acquisition[108]
Nurse Staffing	-	• Number of registered nurses per 100 resident-days associated with reduced MRSA in NH residents[101]
Ownership of Facility	+	• Government-owned facilities more likely to contain MRSA or VRE infected residents[90]
Peripheral Vascular Disease	+	• Antibiotic-resistant infection incidence associated with diagnosis of peripheral vascular disease[136]
Sink Availability	-	• Number of sinks per 100 residents in NHs associated with reduced TMP/SMX-resistant Enterobacteriaceae risk[101]
Wounds	+	• LTCF residents infected with MRSA more likely to have a decubitus ulcer compared to those with MSSA infection[25] • Current wound management and decubitus ulcer positively associated with MDRO colonization among LTCF residents[97] • Current wound management positively associated with R-GNB colonization among LTCF residents[97] • Wound infections and decubitus ulcer associated with MRSA point prevalence among LTCF residents[137]

Note: Assoc. = association with MDRO. LTCF = long-term care facility; NH = Nursing Home; R-GNB = antibiotic-resistant gram-negative bacteria; VRE = vancomycin-resistant enterococcus; MDRO = multidrug resistant organism; MRSA = methicillin resistant *Staphylococcus aureus*; MSSA = methicillin susceptible *Staphylococcus aureus;* TMP/SMX = trimethoprim-sulfamethoxazole.

There is now opportunity to describe MDRO infection in NHs across the U.S. as the revised MDS (3.0) also changed the item capturing antibiotic-resistant infection to recording MDRO infection. While the 2.0 and 3.0 items may capture similar information, no study has explored this updated item to identify predictors of MDRO nationally. MDRO infection recorded on MDS 3.0 is explicitly defined as an active MDRO infection that 1) was diagnosed by an advanced healthcare provider in the past 60 days and 2) had "a direct relationship to the resident's current functional status, cognitive status, mood or behavior status, medical treatments, nursing monitoring, or risk of death" within the past 7 days.[40] Understanding risk factors associated with MDRO infection and effectiveness of isolation precautions is critical to reduce MDRO infection, improve safety and quality of life among long-term care facility residents.

To address these gaps, this dissertation outlines current published effectiveness evidence and cost estimates that may direct use of isolation precautions for MDRO reduction in NHs. Then, it describes the decision-making process among NH staff to implement isolation precautions and other isolation-based techniques. Finally, it explains two quantitative analyses using a large, nationwide dataset to generate new evidence regarding predictors of 1) isolation precautions use and 2) MDRO infection in NH residents. These quantitative analyses have the potential to overcome barriers to external validity encountered by previous studies. Furthermore, it is timely and relevant given the recent changes to the MDS and the national focus on this problem.[168] This new knowledge base will inform infection control practices in NHs and determine areas for future research.

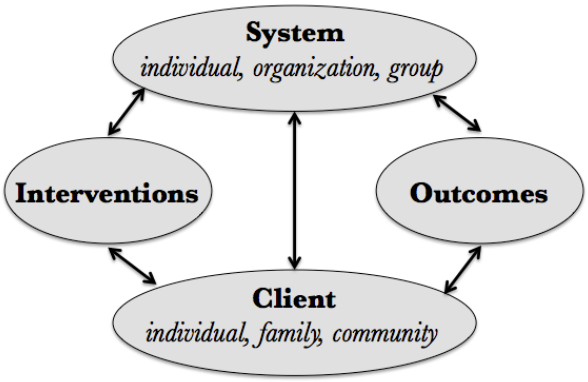
Conceptual Framework

An excellent conceptual framework to guide the study of infection prevention and control activities, especially isolation practices, is the Quality Health Outcomes Model (Figure 1.1).[109] Please see Additional Appendix B, Evaluation of Conceptual Frameworks Applicable to the Study of Isolation Precuations Effectiveness*,* for detailed information regarding the decision to follow this framework while developing this dissertation work.

Building on Donabedian's linear framework of structure, process and outcome of healthcare quality improvement,[63] this dynamic model represents relationships between client characteristics, system characteristics, interventions, and outcomes. Client characteristics include health status, demographics, and disease risk factors of individual residents, families, and communities. System characteristics

incorporate structure and process elements of the Donabedian model (e.g., facility characteristics). Interventions are clinical processes and related activities by which they are performed. Outcomes represent morbidity and mortality. In this model, the relationship between interventions and outcomes is indirect and is mediated by system and client characteristics.[109] A limitation of this model for the proposed study is its lack of a concept that represents biological components of infection risk, such as the virulence of a particular infectious agent. However, presence of a pathogen in the environment may be considered to be a system characteristic. The key strength of this model is that it was developed to facilitate testing complex relationships between constructs with attention to nursing contributions.[110]

Figure 1.1 The quality health outcomes model (Mitchell 1998)



The Quality Health Outcomes Model is an appropriate framework for this dissertation regarding isolation precautions as it aims to link characteristics of the healthcare facility (e.g., low staffing levels), clinical practice interventions (i.e., isolation precautions) with outcomes (i.e., MDRO infections). Considering these relationships as mediated by client characteristics is particularly salient to residential NH settings. For example, NH residents with low cognitive ability may have higher contact with pathogens in the shared environment, thereby increasing infection risk[128] and the goals of care necessitate consideration of resident psychological health more so than in acute care settings.[149]

Aims

Aim 1: Identify and evaluate current effectiveness and cost evidence in the scientific literature that may influence isolation precautions use in NHs.

Content: Aim 1 is addressed in Chapters 2 and 3 of this dissertation.

Aim 2: Describe the decision-making process for and use of isolation precautions in NHs across the U.S. through both qualitative and quantitative methods.

Content: Aim 2 is addressed in Chapters 4 and 5 of this dissertation.

Aim 3: Determine predictors of MDRO infection probability among NH residents across the U.S., including facility and resident characteristics

Content: Aim 3 is addressed in Chapter 6 of this dissertation.

As this dissertation follows the published papers format option, chapters 2-6 each represents a separate analysis and is in the format of an autonomous manuscript prepared for journal publication. The Institutional Review Board of Columbia University approved this dissertation work.

Potential Contributions

This work will be the first to detail use of isolation precautions and MDRO infection risk in NHs nationwide. This study also represents a unique opportunity as first to examine an item novel to the MDS, isolation precautions, and an item updated in the most recent MDS version, MDRO infection. Findings will be relevant to NH staff involved in infection prevention and control activities, public health policymakers, as well as the 1.5 million residents that reside in NH.[168] The results could shift clinical practice and public policy at the state and national levels, especially when linked to Centers for Medicare and Medicaid Services inspection information. For NH staff, it provides valuable information needed to tailor infection prevention decisions to the risk factors and resources of their facility, population and the individual infected resident. Therefore, it will support consistency of decision-making and quality of care in this setting, potentially by strengthening existing guidelines for isolation precautions (i.e., effective decision-making on a case by case basis) and/or identifying new areas for research.

Of note, this dissertation is synergistic with, but distinctly different from, the Prevention of Nosocomial Infections & Cost-Effectiveness in Nursing Homes study (PNICE-NH, R01 NR013687). PNICE-NH is a large mixed methods study, which includes a qualitative component, a survey of NHs and development of multivariate duration and cost-effectiveness models of MDS and Online Survey, Certification and Reporting, now called Certification and Survey Provider Enhanced Reporting (CASPER), and development of a policy model. This dissertation includes secondary analyses of the qualitative and MDS and CASPER quantitative data collected through PNICE-NH. Its focus on isolation precaution use

for MDRO and MDRO predictors using 2010-2013 data offers in-depth analyses on these topics beyond the scope of the PNICE-NH study.

Chapter 2: Effectiveness of Contact Precautions Against Multidrug-Resistant Organism Transmission in Acute Care

The following chapter is a systematic review regarding the effectiveness of contact isolation precautions against multidrug-resistant organism (MDRO) infection. Directed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement, it provides an update to previous reviews regarding contact precautions effectiveness. Unlike older reviews, however, it examines studies with any MDRO as the primary outcome and excludes studies where the effects of contact precautions cannot be separately evaluated from those of other interventions.

Note. The content of this chapter is a manuscript as accepted for publication by the Journal of Hospital Infection. It is now published as:

Cohen, C.C., Cohen, B. & Shang, J. (2015) Effectiveness of contact precautions against multidrug-resistant organism transmission in acute care: A systematic review of the literature. *Journal of Hospital Infection*, *90(4),* 275-284. doi:10.1016/j.jhin.2015.05.003

This article is available online at: http://authors.elsevier.com/sd/article/S0195670115002108

Abstract

Background: Contact precautions are widely recommended to prevent multidrug-resistant organism (MDRO) transmission. However, conflicting data exists regarding their effectiveness. Prior systematic reviews examine contact precautions as part of a larger bundled approach, limiting ability to understand their effectiveness.

Aim: To characterize the effectiveness of contact precautions alone against transmission of any MDRO among adult acute care patients.

Methods: Directed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement, comprehensive searches of four electronic scientific literature databases were conducted for studies published in English from January 2004-June 2014. Studies were included if interventional, original research, evaluating contact isolation precautions against MDRO transmission among inpatients.

Findings: Searches returned 284 studies, six of which were included in the review. These studies measured four different MDROs with one study showing a reduction in transmission. Whereas studies were of high quality regarding outcome operationalization and statistical analyses, but overall quality was moderate to low due to poor intervention description, population characterization and potential biases. Where compliance was measured (n = 4), it presented a threat to validity because measurements included select parts of the intervention, ranged from 21-87%, and was significantly different across study phases (n = 2).

Conclusion: The poor quality of evidence on this topic continues to limit interpretation of these data. Hence, this conflicting body of literature does not constitute evidence for or against contact precautions. We recommend that researchers consider power calculation, compliance monitoring, non-equivalent concurrent controls when designing future studies on this topic.

Keywords: *contact precautions, infection control, infection prevention, multidrug-resistant organism, nosocomial*

Introduction

In 2014, the World Health Organization (WHO) published a report that declared antimicrobial resistance a worldwide problem requiring urgent action.[175] The WHO's report states that most global regions have high resistance to antimicrobial drugs among Staphylococcus aureus, Klebsiella pneumonia and Escherichia coli samples, which are also resistant to multiple antimicrobials.[175] Multidrug resistant organisms (MDROs) are considered to be serious threats to global security[175] as infections with these organisms have higher mortality than those of non-drug-resistant strains,[56] are more difficult[148] and costly[26] to treat. Therefore, identifying and employing effective techniques to control the spread of MDROs is of high importance to manage health outcomes and reduce healthcare costs.[148]

Isolation precautions are the preferred technique to control transmission of pathogens with high morbidity, mortality, or epidemiological significance,[99; 130; 148; 149; 150; 158] but controversy remains regarding the effectiveness of isolation precautions.[178] This debate intensified following transmission of Ebola virus to healthcare workers despite use of isolation precautions.[141] Like Ebola virus, MDROs are spread through direct or indirect contact.[148] Therefore, contact precautions, which include isolation in a private room, if possible, and use of gowns and gloves, are recommended to reduce transmission of MDROs.[149]

However, evidence regarding the effectiveness of contact precautions against MDRO transmission is limited in methodology and content. Prior studies predominantly took place in outbreak scenarios and therefore lack equivalent control group(s)[93] and are subject to performance bias.[2] Additionally, most focused on methicillin resistant Staphylococcus aureus (MRSA) or vancomycin-resistant enterococci (VRE).[2] The effectiveness of contact precautions against emerging MDROs such as carbapenem-resistant Acinetobacter baumannii and beta-lactamase-producing Enterobacteriaceae has not been established.[7; 165] More evidence may be available regarding emerging MDROs since publication of previous reviews. Previous systematic reviews of this topic are similarly limited in the types of MDRO outcomes and have mixed results.[2; 18; 55; 59] More importantly, contact precautions in all of these reviews were grouped with other infection control practices such as active surveillance.[2; 18; 55; 59; 121] Thus, gaps in the literature exist regarding effects of contact precautions alone and against emerging MDROs.[7; 165]

Therefore, the objective of this systematic review is to characterize the effectiveness of contact isolation precautions alone against transmission of any MDRO among adult patients from interventional

studies in which contact precautions are not bundled with other interventions. In order to increase consistency between included studies and better isolate the effect of contact precautions, this review focuses on acute care as other settings such as skilled nursing facilities have different potential for infection transmission.[111]

Methods

This review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement[116] (see Appendix B). Inclusion criteria for studies in this systematic review were 1) original research, 2) published in peer-reviewed, scientific journals, 3) in English, 4) involved human inpatients, 5) conducted in acute care settings, 6) outcomes were infection or colonization with one or more bacterial organisms identified as multidrug-resistant by the Centers for Disease Control and Prevention (CDC)[148], 7) experimental or quasi-experimental design (i.e., interventional) and 8) with intervention of contact isolation precautions (as either the control or experimental exposure). The components of contact precautions required for inclusion were: placement of the infected or colonized patient in a single room or cohorting, use of standard precautions and disposable gown and glove use for close patient contact.[149] Searches were limited to the past 10 years (January 1st 2004 - June 2014) to target the most recent literature (i.e., with emergent pathogen outcomes) as well as literature which was most recent to the publication of most recent clinical guidelines. Editorials, correspondences, commentaries, letters, or proceeding papers were excluded. Studies in which the effectiveness of isolation precautions was indistinguishable from that of a larger intervention bundle were also excluded.

Search Strategy

With the help of a university librarian, searches of PubMed, Ovid Medline, EBSCO Cumulative Index of Nursing and Allied Health Literature (CINAHL) and Cochrane Central Register of Clinical Trials were conducted using the following terms: 1) isolation precautions, 2) multidrug-resistance, 3) bacterial infections, and 4) healthcare-associated infection. The names of specific MDROs identified by the CDC[148] were included as both keyword and medical subject headings (MeSH) terms, where applicable, to maximize search results. Searches also included synonyms, related phrases, and pluralized terms (see Appendix C). Hand searches of reference lists were also conducted.

Study Selection

Two reviewers (C.C.C. and B.C.) screened search results to determine if titles and abstracts met the inclusion and exclusion criteria. Full text of articles were obtained and screened for eligibility when the title and abstract appeared to meet the criteria. All reasons for exclusion were recorded (see Figure 2.1).

Data Abstraction

A data abstraction tool of relevant criteria from The Cochrane Collaboration data collection form for intervention review of randomized controlled trials (RCTs) and non-RCTs was tailored for use in this review.[160] C.C.C. pilot-tested the modified tool (see Appendix D) with two randomly selected eligible papers to confirm appropriateness of the tool and then used it to systematically collect data. These data included rationale for inclusion, methods, participants, intervention groups, outcomes, data and analysis, as well as funding sources, key conclusions, and reported conflicts of interest. C.C.C. contacted the publication's corresponding author if study details were unclear.

Quality Appraisal

Each study was appraised using the quality assessment tool that was developed, piloted, and employed by Aboelela and colleagues to review publications regarding isolation precaution effectiveness[2] (see Appendix E). This tool has items regarding sample representativeness, bias and confounding, description of the intervention, outcomes and follow-up, and statistical analysis, which are each ranked 1-4, where 4 is the highest quality. Each paper was assessed as to whether it addressed the aforementioned categories in a manner that was "completely adequate", "partially adequate", "inadequate, not stated or impossible to tell" or "not applicable". The authors performed component quality analysis independently and discussed results to consensus, as necessary.[102]

Results

The search strategy described above returned 284 publications (Ovid: 165, PubMed: 112, CINAHL: 6, Cochrane: 1). After excluding 129 duplicates, C.C.C. and B.C. reviewed the titles and abstracts of 155 remaining papers. Of these, 126 did not meet the inclusion criteria. The remaining 29 publications underwent full-text review. Hand search yielded five additional papers for eligibility assessment (see Figure 2.1).

The most common reasons for study exclusion were testing an intervention other than isolation precautions (n= 39) or a bundled intervention (n=9); reviewing or presenting data that were not original (n=28); describing the prevalence of MDRO (n=17) or infection prevention practices (n=14); or examining isolation through observation alone (n=16). Of these, three attempted to estimate isolation precaution effectiveness using mathematical models.[45; 57; 92]

Characteristics of Included Studies

Six studies met the inclusion criteria and were included for the final review (Table 2.1). Four studies were non-randomized quasi-experimental studies comparing pre and post-intervention MDRO rates,[14; 15; 44; 53] whereas two studies had a repeated treatment design.[43; 73] One study took place during an MDRO outbreak.[53] Studies included in this review had four different MDROs as primary outcomes, many comparators, and varying methods of identifying MDRO colonization and infection. These fundamental differences prevented meaningful use of meta-analysis to evaluate the effectiveness of contact precautions against MDRO transmission. The small number of studies included in the review and difficulty in identifying and locating unpublished studies also precluded us for an assessment of publication bias.[151]

Population and setting. Included studies were conducted in France,[73] Great Britain,[43] Israel,[53] Hong Kong[44] and the United States.[14; 15] Most studies were conducted in a single acute care center (n=5); [14; 15; 44; 53; 73] one study included two hospitals with analyses done by subgroup.[43] Four settings were noted as academic centers,[14; 43; 44; 73] another as a tertiary care center,[53] and one study's setting was not described.[15] Four studies took place in an intensive care unit (ICU)[14; 15; 43; 44] while the other two applied their intervention throughout the whole hospital.[53; 73] While most studies did not state inclusion or exclusion criteria for the individual patients,[14; 15; 44; 73] one indicated that all hospital admissions were included,[53] and another included those admitted to the ICU for more than 48 hours.[43]

Interventions and comparisons. Almost all papers offered a description of the intervention. Two papers described the intervention by citing CDC guidelines.[14; 15] Variations to these practices and/or additional descriptions regarding the intervention were single-room isolation alone,[53] staff cohorting,[53] regular environmental cleaning[43; 44; 53] and/or environmental cleaning at discharge[43; 44] and reserving healthcare devices (e.g., stethoscopes) for each infected patient.[43]

Most studies (n = 5) compared the effectiveness of contact precautions with the effectiveness of another infection control intervention.[14; 15; 43; 44; 53] These included universal gloving,[14; 15] gowning without moving infected individuals to private rooms[43] and cohorting patients and staff.[44; 53] Cohen et al. also included two additional phases of cohorting, which were increased surveillance in the ICU (phase 3) and active surveillance in the emergency department (phase 4). [53] Bearman et al. (2010) also performed active surveillance, but it was not clear who was subject to screening. One study compared contact isolation precautions against no intervention to prevent transmission of MDRO colonization or infection.[73]

In most of the studies, the authors initiated isolation precautions at the time of a positive MDRO culture (i.e., isolation was not preemptive) and the precautions were initiated for either colonization or infection.[14; 15; 43; 73] Some protocols included cohorting nurse staff members to care for the MDRO-positive patients.[43; 44; 53] One study mentioned that it was possible for patients to be removed from isolation if the patient was MDRO-negative for six months.[53] None of the publications included how long patients were observed to detect occurrence of the outcome. One publication noted that patients who were present during a study phase change were subsequently treated with the intervention of the new phase.[43]

Five studies used pretests and post-tests to compare interventions in the different phases, though most aggregated results by phase[15; 43; 44; 53] or by year.[73] Authors of one study compared MDRO infection rates between the pretest (phase 1) and the removed-treatment phase (phase 2), and phase 2 to the following phase where contact precautions were reintroduced (phase 3).[73] Another study included a concurrent group, though this was a non-equivalent control as MRSA incidence managed with contact precautions was compared to extended spectrum beta-lactamase (ESBL)-producing organism incidence managed with standard precautions (i.e., a different outcome was measured in each group).[44]

Outcomes. MDROs of interest in the included papers were MRSA [14; 15; 43; 44], VRE,[14; 15] carbapenem-resistant Klebsiella pneumonia (CRKP)[53] and drug-resistant A. baumannii.[73] Three studies included measures of more than one MDRO: VRE and MRSA as primary outcomes[14; 15] and ESBL-producing organisms.[44] All of the papers' primary outcomes included colonization with the pathogen of interest in addition to active infection. However, screening procedures to identify cases differed substantially. One study tested the roommates, providers, and immediate environment of active cases to track pathogen spread (active, snowball sampling);[53] another swabbed all patients for MDROs within 24

hours of admission, weekly, at discharge, and as clinically indicated.[43] Two studies tested participants on admission and then every four days or as clinically indicated,[14; 15] while the other two tested for MDRO when deemed clinically necessary.[44; 73]

Analyses. Two of the papers used a Student's t-test and χ^2 or Fisher's exact test to compare continuous and categorical variables, respectively.[14; 15] Others used a Cox-proportional hazards model,[43] Poisson multiple regression analysis,[44; 73] segmented linear regression[44] (including change-point analysis).[53] Two studies reported power calculations to ensure sufficient sample size to detect the anticipated change in infection rate,[14; 43] though in one of these studies the data analysis plan was amended and the power calculation was not changed to reflect the new strategy.[43]

Study conclusions. Five out of the six studies concluded that contact precautions did not represent a statistically significant improvement in MDRO infection control beyond that of the comparator(s) [14; 15; 43; 53]. However, one showed a decreased colonization rate of drug-resistant A. baumannii during periods of contact precautions use compared to a period with no patient isolation (RR 0.5, 95% CI, 0.40– 0.64; $P < 0.001$).[73]

Quality Appraisal

Quality of the included papers ranged widely. While overall quality could be considered moderate for each paper, poor performance on key quality items such as bias and cofounding limits usefulness of this body of literature. Table 2.2 displays a visual representation of each paper's quality along the concepts identified by Aboelela et al. All had at least one quality concept that showed clear opportunity for improvement. Gabaguidi-Hoare et al. did not have a portion of the quality appraisal tool that was deemed "inadequate", but had more "not applicable" items on the quality assessment tool. The following sections outline the rationale for the quality assessment of each paper.

Representativeness. Excepting Cepeda et al. which provided extensive details of the study setting, inclusion and exclusion criteria, and patient population characteristics, representativeness of the included studies was difficult to determine given the poor quality of population and inclusion criteria descriptions. The reviewers determined that most descriptions of the sample population were inadequate or partially adequate because these descriptions, if included at all, frequently lacked immunocompromised status or device use among the included sample,[14; 15; 44; 53] which are known risk

factors for infection.[148] Further, two studies explicitly stated the inclusion and exclusion criteria for enrollment of participants within these setting(s).[43; 53] Given that outcomes appear to include the whole unit or hospital, where no criteria were stated, the reviewers assumed that all patients were included in the study and determined this criterion to be "not applicable" on the quality score. Nevertheless, failing to state this fact represents poor transparency of reporting. All studies provided adequate information regarding setting characteristics, including size and type of facility, type of unit (if applicable) and the hospital location. It was not stated in any study how settings and units within these facilities were chosen for participation, potentially subjecting the included studies to selection bias.[100]

Bias and confounding. The six papers received their lowest evaluations on the quality measures related to bias and confounding. Regarding the potential for sampling and selection bias, the reviewers assumed that the entire facility or unit was included unless otherwise stated. Therefore, the quality criterion for comparing the sample population characteristics to that of a larger population was deemed "not applicable".

The studies had wide quality variation in accounting for confounding interventions. The reviewers interpreted adequacy on this item as noting broad or systemic changes potentially affecting healthcare delivery and attempting to mitigate the effects of the confounder(s), where possible. Two studies were deemed completely adequate in this respect.[43; 44] Cheng et al. identified the severe acute respiratory syndrome (SARS) epidemic and corresponding systemic change as a potential confounder in their study and revised the statistical analysis to account for resulting bias. Cepeda et al. mentioned that environmental services protocols remained unchanged throughout the study and monitored hand hygiene to ensure consistent adherence rates. One study was deemed partially adequate as the facility ICU underwent renovations that doubled the number of beds in preparation for phase two of the study, though the authors confirmed that nurse staff ratios were identical across the phases.[15] This suggests that new nursing staff may have been hired. Though the presence of new personnel can lead to performance bias, this was not addressed in study design.

Some studies were classified as inadequate due to inherent confounding in the study design itself, such as the addition of multiple "bundled" interventions simultaneously.[53] Others were considered inadequate because potential confounders, such as changes in unit occupancy and hand hygiene

adherence, were tracked, but differences across study phases or groups were not accounted for in the statistical analysis.[14] Further, Cohen et al. mentioned that national regulations for infection control changed during the course of the study, making it possible that a novelty effect may have presented a threat to construct validity.[146] Gbaguidi-Haore et al. mentioned no potentially confounding interventions and was therefore scored as "not applicable" on this item.

The level of intervention compliance and quality of compliance monitoring in these studies was mixed and often inadequate. One did not track or report compliance.[73] Another reported compliance inconsistently across different phases of the study[53] and others recorded compliance for particular components of the intervention[43; 44] (e.g., gowning compliance among nurses, but not among other healthcare workers).[43] In contrast, both articles by Bearman et al. measured compliance for all components of the intervention and reported rates during each phase. Given the compliance rates reported by these studies, compliance was determined to be completely and partially adequate, respectively.

Description of intervention. Half the studies' intervention descriptions were completely adequate.[43; 44; 73] Those not deemed to be completely adequate lacked descriptions of the compliance monitoring process,[15; 53] whether gloves were donned upon contact with the patient's immediate environment during isolation,[15] and how compliance was enforced when enforcement was mentioned.[14; 15; 53] Bearman et al. (2007) was inadequate on this item as description of the survey component lacked critical information that would be needed to repeat these methods, including survey format and distribution.[15]

Outcomes and follow-up. The majority of the included papers had high quality operational definitions and assessment description such that methods were reasonably repeatable.[14; 15; 43; 44] Four of six papers completely addressed whether pre-intervention and intervention phase groups were equivalent in follow-up/attrition by showing that length of stay and/or death among participants was equivalent between phases.[14; 15; 43; 73]

Statistical analysis. Statistical validity was generally acceptable in the included studies. Three studies' analyses were deemed "completely adequate", as each included appropriate statistical methods,

clear description of methods, and comparisons between groups.[14; 43; 73] The remaining papers were "partially adequate" as they did not test for differences between groups or variability within them.

Discussion

We reviewed six studies regarding the effectiveness of contact precautions against MDRO infections. Five of the six studies did not find significant association between contact precautions and reductions in MDRO transmission. One study investigating contact precautions for A. baumannii colonization or infection compared against no intervention demonstrated a reduction in the number of cases in phases where isolation precautions were implemented.[73]

Limitations of this review are that it does not include papers published in languages other than English or grey literature. As with all literature reviews, it is also subject to publication bias. However, our findings are consistent with previous literature. De Angelis and colleagues combined results of three studies (including Bearman et al. 2010) in a fixed effects model, despite differences in study interventions, and concluded that contact precautions were not effective against VRE acquisition.[59] A limitation of our review as well as the existing literature may be a failure to address droplet or airborne transmission of these bacteria, which may explain inconsistent effectiveness of contact precautions.[61] However, study quality regarding low compliance rates, bias and confounding, and failure to adjust for confounders and/or confirm equivalency between pre and post-test groups preclude ability to draw strong conclusions from this evidence base regardless of these studies' findings.[93]

Implications for Clinicians

The quality of this body of literature does not justify changes in practice. Conflicting data from studies with poor design and/or low compliance does not constitute evidence against contact precautions; rather, these data are inconclusive. While the study that performed best on our quality score found no significance between contact precautions and not isolating patients, this study did not consistently assess intervention compliance in the various study phases.[43] The included study that showed a difference in MDRO transmission with use of contact precautions did not report compliance rates[73] and could not be assessed for quality on any of the other bias and confounding items of the quality assessment tool. Inconsistencies and absences in compliance monitoring and reporting make it impossible to tell if protocols were completed as intended, threatening the internal validity of these studies.[100] The CDC

recently faced similar difficulty interpreting health outcomes after two healthcare workers were infected with Ebola virus in Texas, as it was unclear whether transmission occurred as a result of inadequate isolation precaution protocols or a protocol breach.[127] In practice, healthcare facilities should be regularly monitoring compliance and investigating potential lapses when cross-transmission is documented to potentially resolve systems-based inefficiencies. It is also important for researchers to monitor and report compliance to understand what effectiveness level can be reasonably expected in practice where compliance may be lower than in clinical studies. Given the quality of evidence presented here, it may be advisable that healthcare workers and administrators continue to devote focus and resources to improve components of contact precautions and other infection prevention techniques with stronger effectiveness evidence, such as hand hygiene technique and compliance.[148]

Implications for Researchers

While the included studies have limitations that have been well-described in the literature on this topic, such as lack of intervention allocation concealment, some demonstrate realistic opportunities for improvement in future studies. First, two of the included papers contained a power calculation.[14; 43] As MDRO infections are rare events and most studies on this topic include small patient samples due to feasibility and cost concerns,[93] future studies should also conduct a calculation to determine whether the study is adequately powered to detect differences in infection rates between intervention phases. Second, four of the included studies attempted to control for time trends in HAI as well as other confounders through statistical analysis.[43; 44; 53; 73] A concurrent, non-equivalent control, such as in Cheng et al., may address this issue, but concurrent controls are not always feasible. In the future, longitudinal studies with multiple pre-intervention collection points could add even stronger evidence[147] by directly measuring and accounting for infection trends that are not related to the intervention, as in Bearman et al. Third, these studies differ from most previous publications by attempting to monitor intervention compliance.[89; 93] Previous studies that monitored compliance demonstrated improved adherence (i.e., with hand hygiene) when an isolation precautions intervention was implemented.[159; 173] However, this was not consistent with levels of compliance reported in the studies reviewed here.[14; 15; 43; 44] Low compliance with contact precautions could be the reason that this intervention appears to be equally or less effective than other

interventions.[43] This body of evidence demonstrates the implementation of a number of improvements in study design which, when combined in future studies, may yield substantially stronger evidence.

Another consideration for future studies is inclusion of patient-centered outcomes. While benefits of isolation precautions are uncertain, adverse consequences of isolation precautions to the isolated individual, such as increased depression, anxiety and anger, are well-documented.[1; 118] A number of papers returned in our search discuss negative consequences associated with isolation,[89; 93; 118; 142; 178] but none of the included papers incorporated patient-centered measures such as anxiety and depression.[104] Considering that patient isolation is relatively resource intensive compared to other infection prevention activities,[65] cost-utility analyses in future studies may be a good option to incorporate health outcomes, patient preferences, and costs to evaluate the effectiveness of contact isolation precautions against MDRO infection.

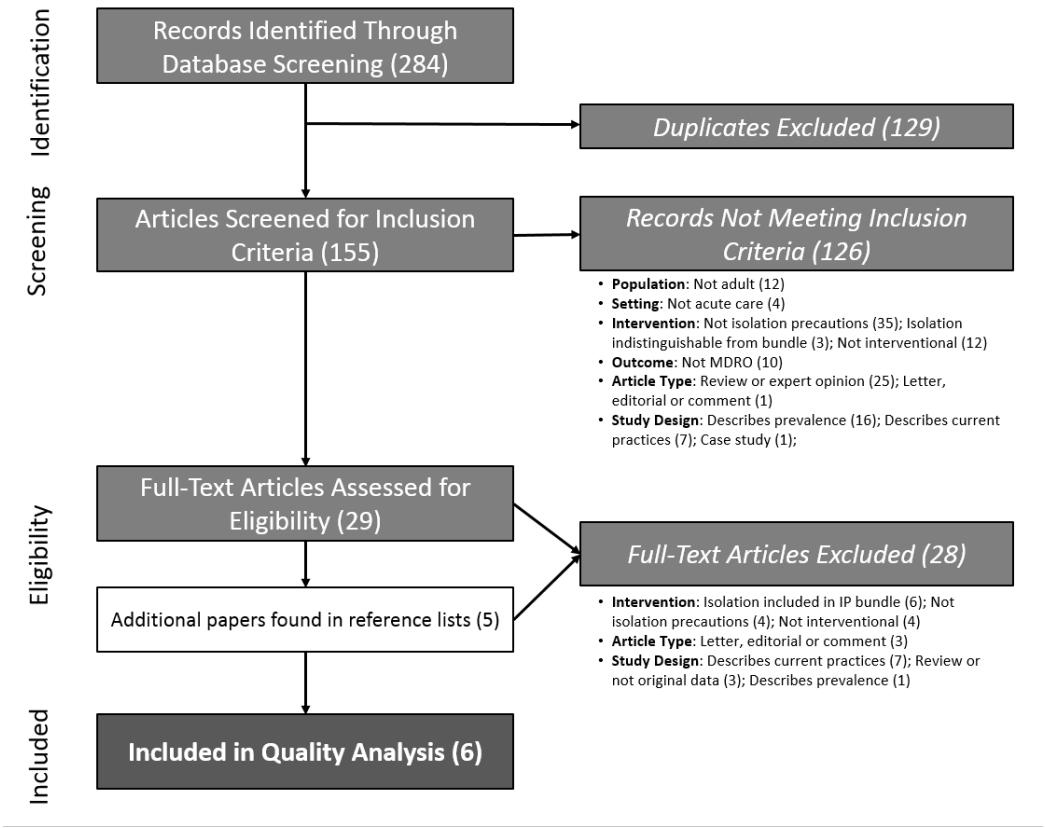


Figure 2.1 Flow diagram of search results and eligibility analysis.

Boxes on the left represent stages of evaluation of the publication returned through electronic database searches. The boxes on the right outline the number of articles excluded by the primary reason for exclusion.

Table 2.1 Summary of characteristics of publications included in the systematic review

Article	Study Design	Setting and Population	Intervention and Comparison	Primary Outcome	Time Horizon (Dates)	Key Conclusions
Bearman et al., 2007	One group pretest-post-test (2 intervention phases)	Medical ICU at academic hospital (United States)	• Contact isolation (phase 1) • Universal gloving (phase 2)	Prevalence and incidence of MRSA or VRE colonization or infection	• Phase 1: 3 months • Phase 2: 3 months (dates not stated)	No differences in the proportion of patients acquiring VRE (14% vs. 18%, p =. 19) or MRSA (5.7% vs. 5% p = .92) in the 2 study phases
Bearman et al., 2010	One group pretest-post-test (2 intervention phases)	Surgical ICU at academic hospital (United States)	• Contact isolation (phase 1) • Universal gloving (phase 2)	Prevalence of MRSA or VRE	• Phase 1: 6 months Phase 2: 6 months (September 2008-September 2009)	No statistically significant change in the rates of device-associated infection, CDI, or MDRO acquisition was observed
Cepeda et al., 2005	Repeated-Treatment	All inpatients with stay >12 hours in 3 medical-surgical ICUs of 2 academic hospitals (Great Britain)	• Gowning and gloving, single room isolation (phases 1 and 3) • Gowning and gloving, no single room isolation (phase 2)	Incidence of MRSA colonization or infection	• Phase 1: 3 months • Phase 2: 6 months • Phase 3: 3 months (June 2000- June 2001)	Risk of acquiring MRSA were similar across phases; combined hazard ratio 0·73 [95% CI 0·49–1·10], p=0·94 (one-sided) and for hospital A and B individually (0·72 [0·44–1·17], p=0·91 and 0·76 [0·37–1·58], p=0·77)
Cheng et al., 2010	One group pretest-post-test with non-equivalent, concurrent control (3 phases)	Patients of a ICU in one university-affiliated teaching hospital (Hong Kong)	• Cohorting (phase 1) • Single room isolation and contact precautions (phase 2) • Single room isolation with hand hygiene campaign (phase 3)	"Changes in the trend or level of incidence density of ICU onset infection due to MRSA" (p. 3)	• Phase 1: 27 months Phase 2: 27 months Phase 3: 35 months (January 2002-June 2009) •	No difference in level or trend change of the incidence density of ICU onset infections due to MRSA and ESBL-producing organisms across different phases

Cohen et al., 2011	One group pretest-post-test (4 intervention phases)	All inpatients of a tertiary care medical center (Israel)	• Contact precautions (phase 1) • Cohorting patients and staff and roommate screening (phase 2) • Phase 2 plus ICU active surveillance (phase 3) • Phase 3 plus ED active surveillance (phase 4)	CRKP colonization or infection "episodes"	• Phase 1: 1 yr • Phase 2: 1 yr • Phase 3: 15 months • Phase 4: 7 months (March 2006-March 2009)	Decrease in incidence rate corresponding with phases 2 and 3
Gbaguidi-Haore et al., 2008	Repeated-Treatment	Academic hospital (France)	• Contact precautions, or cohorting if single room unavailable (phases 1 and 3) • No isolation (phase 2)	Acinetobacter baumannii colonization or infection	• Phase 1: 3 yrs • Phase 2: 3 yrs • Phase 3: 2 yrs (1999-2006)	Implementation of isolation precautions was negatively associated with A. baumannii colonization incidence (RR:0.50 [95% CI: 0.40-0.64]; P<0.001)

Note. ICU = Intensive Care Unit; MRSA = Methicillin-resistant Staphylococcus aureus; VRE = vancomycin-resistant enterococci; CRKP = carbapenem-resistant Klebsiella pneumoniae; ED = Emergency Department; EBSL= Extended Spectrum Beta-Lactamase; CI = Confidence Interval; RR = risk ratio

Table 2.2 Quality assessment results for publications included in the systematic review

Columns represent each concept outlined on the quality assessment tool and each row represents an included paper. Cell color corresponds to quality level as per the key.

Quality Criterion:	Bearman et al., 2007	Bearman et al., 2010	Cepeda et al., 2005	Cheng et al., 2010	Cohen et al., 2011	Gbaguidi-Haore et al., 2008
Representativeness						
Study population description	3	2	4	2	2	4
Inclusion/exclusion criteria	1	1	4	1	1	1
Location/setting description*	4	4	4	4	4	4
Bias and Confounding						
Study population corresponded to larger population in all key factors	1	1	1	1	1	1
Masking	1	1	1	1	1	1
How similar was the assessment of outcomes between groups	1	1	1	1	1	1
Involvement from author	1	1	1	1	1	1
Accounted for confounding interventions	3	2	4	4	2	1
Compliance rate	4	3	2	2	2	1
Description of Intervention						
Replication possible given descriptions of intervention	2	3	4	4	3	4

Key: 4 = Completely Adequate; 3 = Partially Adequate; 2 = Inadequate, Not Stated; 1 = Not Applicable

Quality Criterion:	Bearman et al., 2007	Bearman et al., 2010	Cepeda et al., 2005	Cheng et al., 2010	Cohen et al., 2011	Gbaguidi-Haore et al., 2008
Outcomes and Follow-up						
Outcome assessment procedure clearly defined	4	4	4	4	3	3
Groups equivalent in attrition/LOS/death/patient days	4	4	4	2	2	4
Statistical Analysis						
Description and appropriateness of methods	4	4	4	4	4	4
Tested differences between groups and variability	2	4	4	2	2	4

Key: 4 = Completely Adequate; 3 = Partially Adequate; 2 = Inadequate, Not Stated; 1 = Not Applicable

Note: *Added to quality assessment tool described by Aboelela et al. (2006); LOS = Length of stay.

Chapter 3: Costs of Infection Prevention Practices in Long-term Care Settings

The following chapter is a systematic review of scientific literature containing cost estimates of infection prevention activities in long-term care facilities. Guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement, the review analyses the quality of identified cost estimates and addresses implications for nurse administrators, educators and clinicians, as well as researchers.

Note. The contents of this chapter are the manuscript accepted for publication by *Nursing Economic$.*

Cohen, C.C., Choi, Y. & Stone, P.W. (In Press). Costs of infection prevention practices in long-term care settings: A systematic review. *Nursing Economic$*

Abstract

Research Objective: Healthcare-associated infections represent a significant cause of morbidity and mortality for the 2.5 million Americans residing in long-term care facilities (LTCFs). As the elderly U.S. population relying on LTCF services continues to grow, it is critical to establish efficient infection prevention activities in this setting. Evidence-based cost considerations may inform clinical decisions how best to prevent infection given constrained resources. The objective of this systematic review is to identify and evaluate cost estimates reported in the scientific literature of structures and processes intended to prevent infection among residents and staff of LTCFs included in any study design from institutional, societal or public health perspectives.

Study Design: This study is a review of scientific literature directed by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Five web-based databases were searched for peer-reviewed scientific articles: PubMed, Ovid Medline, Scopus, EBSCO Cumulative Index of Nursing and Allied Health Literature (CINAHL) and Cochrane. Publications with original cost estimates of infection prevention activities were included if published in English within the past 25 years. Studies were included if interventions to prevent infection, as determined by the Epidemiologic Triad of Disease conceptual framework, pertained to LTCFs and cost perspective was not exclusive to another setting. Following title and abstract screening, full texts were obtained for further evaluation. Two reviewers performed data abstraction guided by the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement and quality assessment was conducted using the Quality of Health Economic Studies (QHES) tool. Disagreements were resolved by discussion between the two reviewers and, if necessary, consultation with a third reviewer.

Population Studied: Residents and staff of LTCFs

Principal Findings: Of the 773 studies initially identified, 22 studies underwent full text assessment. Nine studies were deemed eligible for inclusion. Research designs included cohort (n = 4), quasi-experimental (n = 2), Markov model (n = 2) and randomized control trial (n = 1). Four studies were cost-analyses.

Included studies represented wide variety of interventions, outcomes and cost measures, preventing aggregation of findings. Most were low to moderate quality given lack of information regarding study methods, especially the cost measurement perspective, data collection time horizon, model or calculation justification and anticipated bias magnitude and direction. However, many included studies received higher QHES quality scores due to transparent justification for conclusions, explicitly stated primary and secondary outcomes and having collected data from the best available source(s).

Conclusions: There were few publications identified in this scientific literature review that examined cost of different infection prevention interventions in LTCFs. These studies were of moderate to low quality and it was not possible to compile and compare their results. Future researchers should improve the quality of study design and transparency of the corresponding manuscripts through use of a health economic analysis checklist.

Implications for Policy and Practice: The body of literature regarding costs of infection prevention in LTCFs does not support changes to policy or practice at this time. Future high-quality studies may greatly contribute to clinical decision-making and thereby reduce infection in LTCFs.

Keywords: *Long-term care; cost analysis, infection prevention*

Introduction

Healthcare-associated infections (HAI) represent a significant cause of morbidity and mortality for the 2.5 million Americans residing in long-term care facilities (LTCFs) [157]. According to the U.S. Department of Health and Human Services, LTCFs are institutions that provide healthcare programs and services outside of an acute care hospital and encompass both skilled nursing facilities and nursing homes [168]. Within U.S. nursing homes alone, an estimated 1.6 to 3.8 million HAI occur annually. These HAI cost $38-$137 million for antimicrobial therapy and $673 million to $2 billion for hospitalizations due to infections each year [27; 29]. The Centers for Disease Control and Prevention (CDC) recognize that reducing HAI is a priority that extends to all LTCFs [149], considering that most HAI can be prevented through appropriate infection control and prevention practices [152].

Long-term care demographic and industry trends challenge provision of effective care and infection prevention. The average long-term care resident today is older, with higher case acuity and complexity than two decades ago [117], and is thereby more vulnerable to infection [149]. However, infection control and prevention efforts must compete for resources with other care priorities as most LTCFs face increasing budget constraints following Medicare's shift to a prospective payment system though the Balanced Budget Act of 1997 [17]. Given lower, bundled reimbursement rates, there is a need for evidence-based efficiency improvements, and more specifically, a need to weigh benefits and costs of infection-control activities in non-acute settings [70].

While the financial burden of some HAI have been characterized in this setting [26; 85], there are a limited number of papers that address the costs of efforts to prevent HAI. Analyzing the balance between relative costs as well as benefits of infection prevention activities is particularly important to this residential population among which efforts to reduce infection may have detrimental effects with respect to resident psychological health [149] and quality of life [8].

A systematic review of literature to weigh benefits, costs, and harms of clinical practices in LTCF and thereby inform decisions of infection prevention coordinators in this setting would be useful [120]. To our knowledge, no such systematic review has been previously published.

Objective

The objective of this systematic review is to identify and evaluate cost estimates reported in the scientific literature of structure and processes intended to prevent infection among residents and staff of LTCFs.

Theoretical Framework

The Epidemiologic Triad of Disease informed identification of activities intended to prevent infectious disease. This theoretical framework outlines the concepts of host (long-term care resident or staff), agent (pathogen) and environment and their relationships to each other to perpetuate infectious disease transmission [47]. Activities intended to reduce host susceptibility, agent presence (or virulence) or environment severity were therefore considered an infection prevention practice.

Methods

The authors followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement [116] to conduct this systematic review (see Appendix B).

Eligibility Criteria

Inclusion and exclusion criteria were developed based on the following core elements: publication type and date, setting, conditions, study subjects, and perspectives. Inclusion criteria for this review were as follows: 1) original research published in a peer-reviewed, scientific journal in the English language within the past 25 years (1989-2013); 2) setting was long-term care; 3) the research focus was infection prevention or controlling outbreaks; 4) study subjects were either residents of or healthcare workers in the LTCFs; and, 5) the study included an analysis from institutional, societal or public health perspectives to identify cost estimates most relevant to LTCFs.

Excluded studies met the following criteria: 1) the study was an editorial, correspondence, commentary, letter, or proceeding paper; 2) the study setting was any other than LTCFs, such as acute-care hospitals; and, 3) the study perspective was exclusive to another setting such as a hospital.

Search Strategy

With the help of university librarians, the first author, C.C.C., conducted scientific literature searches in June-July 2013 within the following online databases: PubMed, Ovid Medline, Scopus, EBSCO Cumulative Index of Nursing and Allied Health Literature (CINAHL), and Cochrane. To maximize

results, searches included both keyword and medical subject headings (MeSH), where applicable, and combined terms describing the intended setting ("nursing home", "nursing facility", "skilled nursing facility", "long-term care", "aged home", "extended care") with "infection" or "cross-infection" and "cost" or "economic".

Study Selection

One reviewer (C.C.C.) performed an initial screen of the titles and abstracts of the search results according to the inclusion and exclusion criteria. When the title and abstract appeared to meet the inclusion criteria, or this information was not enough to determine whether the study met the inclusion criteria (i.e., publication had no abstract) the full text was obtained and reviewed. All the authors discussed eligibility of publications that were likely or borderline for inclusion. Final inclusions were determined by consensus, and the reasons for exclusion were recorded.

Data Abstraction

Two reviewers, Y.J.C and C.C.C., each abstracted data from eligible papers and confirmed the accuracy of each other's work in congruence with the Consolidated Health Economic Evaluation Reporting Standards (CHEERS) statement [84] (see Appendix F). Data elements and operational definitions that comprise the recent and relevant 24-item CHEERS checklist (e.g., target population, comparators, health outcomes) are described elsewhere [84]. Disagreements were resolved by discussion between the two reviewers and, if necessary, consultation with a third reviewer.

Summary measures such as cost perspective, data source(s) and measurement time horizon were compiled. Cost estimates reported in non-U.S. currencies were converted to United States Dollars (USD) using the Economic Research Federal Reserve Bank of St. Louis FRED II foreign exchange rates for January 1st of the study publication year (or year of cost estimate collection, if stated) [69]. The authors also standardized cost estimates into 2013 USD values using Bureau of Labor and Statistics Consumer Price Index calculator [23].

Quality Appraisal

Two reviewers (C.C.C., Y.J.C.) then independently assessed the quality of included studies using the Quality of Health Economic Studies (QHES) instrument (see Appendix G). QHES is a validated, pilot-tested tool, which includes 16 quality indicators with binary outcomes that can be weighted, then summed

to a score ranging from 0 (lowest quality) to 100 (highest quality). QHES, while directed towards health economic analyses, can guide evaluation of bias in multiple study designs [94].

The reviewers agreed to a number of interpretations of QHES items before assessing the quality score of included papers. For example, if the cost estimate was not the primary outcome, the objective statement did not need to mention cost evaluation to achieve a high quality score. When the QHES quality items regarding model components and justification were not relevant, studies were evaluated with regards to study calculations. When studies did not include subgroup evaluation, the item regarding subgroup pre-specification was not relevant and the reviewers evaluated whether study authors had assessed the need for subgroups (i.e., any discussion of population heterogeneity).

The reviewers used the weighting system to calculate quality scores created by the QHES authors. The QHES quality score accounts for an item's contribution to the perceived overall quality of the paper. This included multiplying the outcome of each item (i.e., 1 or 0) by the weighting of each item recommended by the QHES authors [84] before summing the outcomes of each item to generate the overall quality score. All disagreements regarding quality assessments were resolved by discussion between the two reviewers and, if necessary, consultation with a third reviewer.

Results

Results of Study Selection

In total, 773 studies were identified by initial database search. After duplicates were removed (n = 350), 423 studies were eligible for screening by title and abstract; of these, 22 studies were identified for full-text assessment. **Figure 3.1** shows the study selection process leading to the inclusion of 9 studies for the systematic review.

Of the 22 papers that underwent full text review, the primary reason for exclusion was that the intervention of interest was not sufficiently focused on infection prevention. Papers that required extensive discussion but were ultimately excluded for this reason were an evaluation of a skin tear treatment that may prevent infection by closing open wounds, but was not antibacterial [107], a comparison of infection surveillance techniques that could theoretically reduce infections as a result of interventions following surveillance [46], but not directly from the surveillance techniques under consideration, and a comparison of enteral feeding techniques to reduce bacterial contamination of feeding bags, which could theoretically

reduce GI infection, though this was not an outcome of the study [115]. Another study was also excluded after careful deliberation as it addressed an intervention in both an acute care and a LTCF setting, but then appeared to provide cost of the intervention to the hospital rather than that of the LTCF [21]. Others were excluded after it was determined that the cost estimates were not original research (i.e., they had previously been published, n = 2), found to be a published correspondence on further review (n = 1) or determined that the study's intervention and cost measurements took place in a setting that did not meet inclusion criteria (n = 2).

Included Study Characteristics

Included studies employed observational designs [8; 60; 64; 95] and interventional designs [66; 86; 135]. A minority of the studies' samples specifically included residents of nursing homes (n = 3) [64; 66; 135], as opposed to skilled nursing facilities. Of the 9 studies included, approximately half were published in the 1990s (n = 5) [8; 66; 86; 95; 103]. Most studies were performed in either the United States (n = 5) [64; 66; 86; 95; 135] or Canada (n = 3) [8; 60; 103], and one study was completed using cohort data from Hong Kong [177]. Table 3.1 summarizes characteristics of the eligible studies, including objective, study design, study population, setting, time horizon, outcome measures, results and QHES quality score.

Data Abstraction Results

Most studies reviewed infection prevention interventions for a specific disease, such as vancomycin-resistant enterococcus (VRE) (n = 1) [8], methicillin-resistant *Staphylococcus aureus* (MRSA) (n = 2) [86; 95], or tuberculosis (n = 1) [103]. In two studies, the interventions were aimed at preventing urinary tract infections, as well as other diseases and conditions [64; 135]. Given the diversity of infection prevention activities addressed, as well as the variety in study designs, outcome synthesis was not possible.

Cost estimates most often included additional staff time for an intervention (n = 6) [8; 60; 66; 103; 135; 177], increased use of disposable items such as gowns and gloves and incremental use of cleaning supplies (n = 6) [8; 60; 66; 86; 95; 135]. These expenditures were often the market price per unit multiplied by the number of units used. Four papers included a statistical analysis, and the same four displayed differences in cost and outcomes between two alternative infection prevention practices [64; 66; 103; 177]. Only three studies provided sensitivity analyses of cost estimates [64; 103; 177].

Three publications specifically reported the perspective of the cost estimate including societal [64], healthcare system [103], and public health care provider [177]. Dorr et al. (2005) also included a sub-analysis from an institutional perspective. Four of the eligible papers included a cost analysis: one cost-utility [103], one cost-benefit [86], and two cost-effectiveness [66; 177]. In the majority of studies, the investigators indicated the specific abstraction method through which the primary outcome measure and costs were determined (n = 6) [8; 64; 66; 95; 103; 177]. Two papers included a model of cost estimates [103; 177]. None of the included studies' authors performed a subgroup analysis. Only four papers contained discussion of the homogeneity of the study population [60; 64; 66; 135], likely due to the fact that most included a single LTCF (n = 5) [8; 60; 86; 95; 135]. As most papers did not discuss homogeneity of study population characteristics, this limited the ability to determine generalizability of the study and potential sampling bias.

While some authors discussed limitations of their respective study [8; 64; 177], only Larson et al. (1992) included discussion of the magnitude and direction of potential biases on the cost estimates [95].

Results of Quality Assessment

The QHES scores ranged from 22 to 94, with an average of 56.6. Figure 3.1 shows the results of quality assessment using the QHES instrument. In this figure, the length of the bar indicates the number of the studies achieving high quality regarding each item.

Six of the studies included a high-quality, specific objectives statement, which had a stated measurable outcome of interest, setting or population, and intervention, if applicable [8; 64; 66; 95; 103; 177]. Most study designs appeared to be the most appropriate method of determining relevant health outcomes and cost (n = 8) [8; 60; 64; 66; 86; 95; 103; 177]. However, time horizon was not clearly appropriate to effectively assess health outcomes in a number of publications [8; 60; 66; 86; 135]. For example, a study of an intervention to eradicate a scabies outbreak from a single facility had not eradicated scabies from the institution by the end of the study as treatment failures occurred later that year [60]. Measures of health outcomes were sufficiently validated and/or justified in six of the nine publications [8; 64; 95; 103; 135; 177]. The majority of papers received lower quality scores for both a lack of statistical analysis and lack of comparison to alternatives (n = 5) [8; 60; 86; 95; 135].

Cost estimate measurements and calculations were often unclear and the source and calculation of the estimates was not stated (n = 4) [60; 66; 86; 135]. As noted above, most papers did not explicitly state the

perspective from which the cost estimates were measured (n = 6), which is especially critical to evaluate whether all relevant costs were included and measured appropriately. Furthermore, only two papers avoided bias by stating a clearly appropriate time horizon or discount rate (n = 2) [64; 95]. One paper that collected data over three years did not mention how these costs were discounted, if at all [86] and those that used a discount rate did not provide justification for that specific rate (n = 2) [103; 177].

Transparency regarding primary and/or cost outcomes and stated conclusions were directly justified by study findings improved the quality of all included papers. However, most papers received a lower quality score for lacking a discussion of study limitations (n = 6) [8; 60; 66; 86; 95; 135].

Discussion

Of the studies deemed eligible for inclusion, most were low to moderate quality given lack of information regarding study methods, especially the cost measurement perspective, data collection time horizon, model or calculation justification and anticipated bias magnitude and direction. However, many included studies received higher QHES quality scores due to transparent justification for conclusions, explicitly stated primary and secondary outcomes and having collected data from the best available source(s).

It is possible that many poor scores on the quality assessment items might indicate lack of publication transparency rather than methodology sophistication or accuracy. For example, stating the perspective from which costs were determined can substantially improve the readers' ability to determine generalizability and cost estimate applicability. Future cost and cost analysis studies regarding infection prevention in LTCFs may improve on the current body of work by ensuring that the manuscript addresses all items in the CHEERS, QHES or a similar health economic publication checklists and we encourage authors, reviewers and editors to use these developed checklists.

The small volume of publications regarding the cost of infection prevention in LTCFs identified in the scientific literature cover a wide variety of interventions. Given the diversity of study designs in the papers, health outcomes and cost measures, further generation of evidence would be required to meaningfully aggregate and compare results of these studies. Our findings are similar to those of Stone, Braccia and Larson (2005). These authors reviewed economic analyses related to HAI in multiple settings. While their results demonstrated an increasing quality of cost analyses over time, the existing

body of literature did not offer specific public policy or practice implications at that time [155]. In our review, most of the authors derived cost estimates from a single LTCF. The high heterogeneity of populations and service specialization of LTCFs limits the external validity of these studies [168]. Furthermore, it is unlikely that study methodology and calculation of cost estimates could be repeated given the information provided in these publications. Therefore, as in Stone et al. (2005), we also cannot recommend specific infection prevention practices based on cost estimates or cost-effectiveness based on these data.

Implications for Policy, Practice and Education

The rising costs of infection in LTCFs without attention to prevention may result in three different scenarios. First, LTCFs may be able to secure new funding to cover the rising costs of infection. However, this is likely to continue increasing the costs of treatment and is ultimately unsustainable [123]. Second, in the absence of sufficient funding, LTCF executives might shift resources from other budget items to cover increased costs of infections, which may be detrimental to other areas of care. Last, LTCF exceed their budgets, possibly resulting in facility closures. Given these scenarios, investments in infection prevention is much more acceptable. Considering that an estimated 380,000 LTCF residents die of infection annually [33] and that the nursing home population alone is expected to grow from 1.5 million today to 5.3 million by 2030 [157], it is important to invest in infection prevention activities to reduce morbidity, mortality in this vulnerable population as well as reduce costs to LTCFs and the already overburdened U.S. healthcare system.

Cost-effectiveness research is needed to inform nurse executives' decisions on how best to prevent infections, which should avoid adverse events among residents and curb program costs [124]. In acute care, multifaceted infection prevention programs have been found to be cost-saving [62] and while there are as of yet, no well developed economic models of infection prevention in LTCFs, it is likely that they will also be found to be cost-saving. However, where multiple alternative processes exist to prevent infection, deciding between alternative structures, practices or products requires not only knowledge of the relative intervention effectiveness but also the cost trade-off for that level of effectiveness [71].

Therefore, nurse executives should consider costs as well as health outcomes when generating new policy regarding procedures or products related to infection prevention. In doing so, administrators should cautiously evaluate the recommendations of published studies containing a cost estimation based

on the quality of the estimate in addition to assessing applicability of the results to their own facility and resident population. Unfortunately, the authors have no knowledge of additional sources of cost estimates for infection prevention activities in LTCFs at this time beyond publications reported in this review. As demonstrated in this review, those who wish to evaluate others' cost estimates or establish one tailored to their own facility may wish to pay particular attention to the time horizon in which both health and cost outcomes occur, costs from the perspectives of multiple stakeholders (i.e., what costs exist to facility, staff, patients and payers) and the additional time required from staff. For example, while many of the included studies measured additional staff time required for the intervention in this review, none included the resources required for educational in-services regarding the intervention. This may be a key consideration depending on available resources and need for staff compliance with the new policy.

To prepare future nurse leaders to meet the challenges of evaluating costs of infection prevention (and other quality improvement activities), nurse educators should include economic evaluations in curricula, if these factors are not already included. Indeed, understanding healthcare financing, business principles and how they influence clinical outcomes and cost factors is an American Association of Colleges of Nursing essential element in baccalaureate education [4].

Better understanding of economic analysis concepts, such as those included on the economic evaluation tools used in this study, may improve future nurse executives' interpretation of the scientific literature and application to clinical practice. In this way, future studies may substantially contribute to clinical decision-making to reduce infection in LTCF.

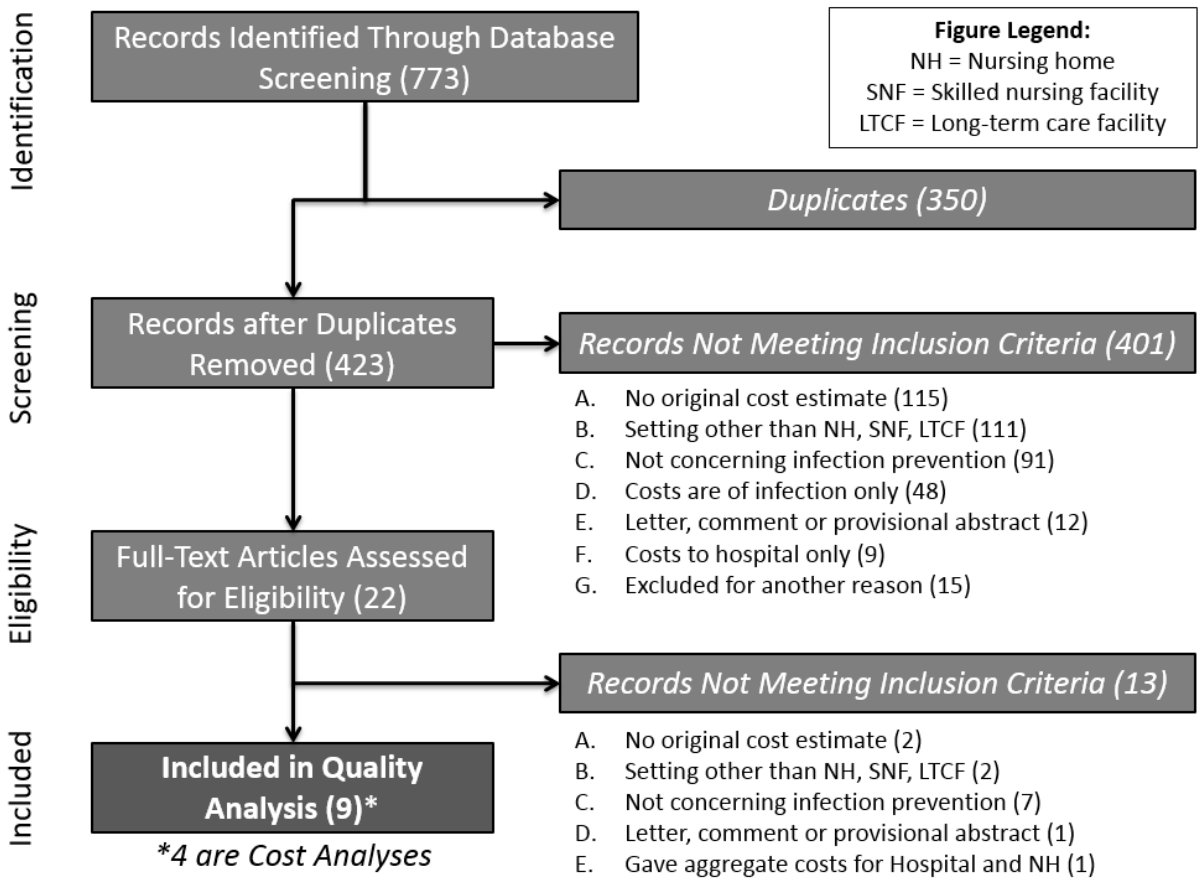


Figure 3.1 Systematic review of infection control cost estimates flow diagram of search results and eligibility.
Boxes on the left represent stages of evaluation of the papers returned through the original electronic database searches. The boxes on the right show how many articles were excluded by the primary reason for exclusion.

Table 3.1 Summary of studies included in the systematic review of infection control cost estimates

First Author	Year	Objective	Sample/ Setting (Country)	Study Design (Time Horizon)	Health Outcomes	Infection Prevention Resources	Cost Estimate	QHES Score
Armstrong-Evans [8]	1999	To describe the investigation and control of transmission of VRE in a residential LTC setting	5 residents of 1 LTCF (Canada)	Prospective cohort (13 months)	Resident VRE colonization	Disposable supplies; cleaning and disinfection; reusable gowns; personal care caddies; staff time; formal education; screening	Total cost of intervention: $11,379.00	49
De Beer [60]	2006	To describe a scabies outbreak and determine whether the effectiveness of the treatment protocol justified its future use	387 residents and 700 staff of 1 LTCF (Canada)	Retrospective cohort (2 months)	Incident cases of scabies	Topical permethrin; overtime and additional salary costs; security guard salary; disposable gowns and gloves; cleaning supplies; laundry	Total costs of outbreak minus treatment: $144,977.00	23
Dorr [64]	2005	To examine potential cost savings from decreased adverse resident outcomes versus additional wages of nurses when nursing homes have adequate staffing	1376 residents of 82 NHs (United States)	Retrospective cohort (1 year)	UTI rate	RN wages and benefits; Hospitalization	Cost savings per 100 NH residents per year: $40,724.83	61

First Author	Year	Objective	Sample/ Setting (Country)	Study Design (Time Horizon)	Health Outcomes	Infection Prevention Resources	Cost Estimate	QHES Score
Duffy [66]	1995	To compare the safety and cost of clean versus sterile intermittent bladder catheterization in male nursing home residents To decrease MRSA colonization and infection rates and prevent the introduction of additional colonized patients into a closed nursing home environment	80 male veterans in 3 VA NHs with need for catheterization (United States) 42 residents in 1 extended care unit of VA hospital (United States)	Randomized clinical trial (125 days), with cost-effectiveness analysis Quasi-experimental with cost-benefit analysis (3 years)	UTI; Pressure ulcer; Hospitalization rates MRSA colonization rate; MRSA infection rate; difference in colonization and infection rates pre-and post intervention	Nurse time and supplies for catheterization PPE; medications; nursing and environmental management services; laboratory costs; miscellaneous items;	Incremental cost of sterile vs. clean catheterization per 1 catheterization: $3.23 Total cost of intervention: $32,242.24	94
Jaqua-Stewart [86]	1999							22
Larson [95]	1992	To examine the prevalence of C. *difficile* and MRSA resident on hands of nursing staff of a 233-bed long-term care facility during a 24-hour period, as well as the prevalence of C. *difficile* and MRSA carriage of patient in the wad with expected high rates of C. *difficile* and MRSA carriage and in the adjacent wards	207 residents and 84 staff of 1 LTCF (United States)	Prospective cohort (6 months)	Chronic hand carriage of C. *difficile* and MRSA among healthcare workers; C. *difficile* and MRSA colonization rates among residents	Gloves	Mean cost of gloves per month in LTC: $2,253.89; Mean cost of gloves per month in SN unit: $376.20	73

First Author	Year	Objective	Sample/ Setting (Country)	Study Design (Time Horizon)	Health Outcomes	Infection Prevention Resources	Cost Estimate	QHES Score
Marchand [103]	1999	To determine if the more interventionist approach of screening with the tuberculin test and chemoprophylaxis for high-risk positive reactors to control tuberculosis in long-term care facilities is cost-effective when compared to the case-finding and treatment approach	Newly admitted residents to 1 LTCF (Canada)	Cost-utility decision-analysis model (15 years)	Life-year (LY); quality-adjusted life-year (QALY); annual Tb cases; Tb-related deaths	Staff time; screening supplies	$4,734.21 per LY; $3,782.41 per QALY	83
Robinson [135]	2002	To determine the effect of a specific program on the level of hydration and the prevention of conditions associated with dehydration	51 residents in 1 NH (United States)	Quasi-experimental (9 weeks)	Total body water; Intracellular body water; Extracellular body water; delirium; UTI; respiratory infections; falls; skin breakdown; constipation	Staff time; beverages; cups	Total cost of intervention: $210.31	25

First Author	Year	Objective	Sample/ Setting (Country)	Study Design (Time Horizon)	Health Outcomes	Infection Prevention Resources	Cost Estimate	QHES Score
You [177]	2009	To compare cost and QALYs gained by influenza vaccination alone and in combination with pneumococcal vaccination in elderly people living in long-term care from a Hong Kong public health provider's perspective	1016 hypothetical elderly LTCF cohort (Hong Kong)	Cost-effectiveness analysis with Markov model (5 years)	Quality-adjusted life years (QALYs); death	Cost of vaccine, RN time for administration; RN treatment of vaccination side effects	Total cost of intervention: $202.48; Incremental cost per QALY gained for influenza and pneumonia vaccines vs. influenza vaccine alone: $544.30	83

Note. [a]QHES quality assessment score range is 0 (worst) to 100 (best); LTCF = Long-Term Care Facility; NH = Nursing home; VA = Veteran's Administration; UTI= urinary tract infection; VRE= vancomycin-resistant enterococcus; Tb = Tuberculosis; PPE = personal protective equipment; RN = registered nurse; QALY=quality-adjusted life year; SN = skilled nursing.

Chapter 4: A Qualitative Study of Decision-Making Regarding Isolation-Based Practices

The following chapter describes a qualitative study of variation in the decision-making process to use isolation-based infection prevention practices in nursing homes (NHs). Following the consolidated criteria for reporting qualitative research checklist, this manuscript thematically characterizes the factors influencing which residents are isolated, under what circumstances and how so. This topic is relevant to identify how NH staff understanding and perceptions are shaping current infection control and prevention practices.

Note. The contents of this chapter are a manuscript accepted for publication by BMJ Quality & Safety, which is now published as:

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Abstract

Background: Isolation-based practices in nursing homes (NHs) differ from those in acute care. NHs must promote quality of life while preventing infection transmission. Practices used in NHs to reconcile these goals of care have not been characterized.

Purpose: To explore decision-making regarding isolation-based infection prevention and control practices in NHs.

Methods: A qualitative study was conducted with staff (e.g., staff nurses, infection prevention directors and directors of nursing) employed in purposefully sampled U.S. NHs. Semi-structured, role-specific interview guides were developed and interviews were digitally recorded, transcribed verbatim and analyzed using directed content analysis. The research team discussed emerging themes in weekly meetings to confirm consensus.

Results: We inferred from 73 interviews in 10 NHs that there was variation between NHs in practices regarding who was isolated, when isolation-based practices took place, how they were implemented, and how they were tailored for each resident. Interviewees' decision-making depended on staff perceptions of acceptable transmission risk and resident quality of life. NH resources also influenced decision-making, including availability of private rooms, extent to which staff can devote time to isolation-based practices and communication tools. A lack of understanding of key infection prevention and control concepts was also revealed.

Conclusions and Implications: Current clinical guidelines are not specific enough to ensure consistent practice that meets care goals and resource constraints in NHs. However, new epidemiological research regarding effectiveness of varying isolation practices in this setting is needed to inform clinical practice. Further, additional infection prevention and control education for NH staff may be required.

Keywords: *Decision making; Infection control; Nosocomial infections; Nursing homes*

Introduction

Infections are a leading cause of morbidity and mortality among nursing home (NH) residents.[134] In the U.S. alone, an estimated 1.6 to 3.8 million infections occur in NHs annually.[157] Because NH residents are at high risk for infection,[148] prevalence will likely continue to rise given the global aging population[174] that will increase demand for NH services (1.5 million U.S. residents today[168] compared with an estimated 5.3 million by 2030[157]). Therefore, identifying effective practices to reduce infection transmission is necessary to manage health outcomes and costs.[148]

Isolation precautions are recommended to prevent the spread of pathogens associated with high morbidity and mortality, such as multidrug-resistant organisms (MDROs).[130; 149; 150] This practice includes confining an MDRO-infected resident to a private room or cohorting if no private rooms are available (i.e., grouping together patients colonized or infected with the same organism by location during all activities to prevent organism transmission to unaffected patients).[9; 54; 130; 149; 150] Infection prevention guidelines also suggest using standard precautions for contact with the MDRO-infected resident (i.e., hand hygiene, use of gowns, gloves and other personal protective equipment depending on the anticipated exposure).[149] Further, it is recommended that infected residents should have dedicated disposable patient care equipment,[9] such as private commodes for patients with a diarrheal disease, if private bathrooms are not available.[54] Studies concerning the effectiveness of isolation precautions have had mixed results and have been deemed to be of moderate or poor quality.[2; 59]

Infection prevention and control guidelines are based on evidence collected in acute care settings, and therefore are not always practical or appropriate in NHs where resources are more constrained and the healthcare facility is often the residents' home.[149; 150] Further, isolation has well-established negative psychological effects,[77; 118] both for semi-private and private room isolation.[77] These adverse effects may be of greater concern in a NH facility since it is also a primary residence. A qualitative description of isolation-based infection control practices in this setting has not been conducted. Therefore, it is important to understand how NH staff balance benefits and drawbacks of isolation in order to establish best practices that can be implemented across facilities.[20]

A gap in the literature exists regarding how it is decided when and how to implement isolation of infected residents in this setting. In a previous survey of 331 NHs in Iowa, most facilities reported use of

isolation precautions for methicillin-resistant *Staphylococcus aureus* or vancomycin-resistant enterococcus infections. The majority also reported cohorting some residents infected with these organisms. Staff in approximately a third of the NHs reported that the need for private room placement depended on the particular resident. However the survey did not capture how it was determined that isolation or cohorting was appropriate,[90] thus providing limited insight into factors that may influence isolation practices versus cohorting. Therefore, the objective of this study was to explore decision-making in isolation-based infection prevention and control practices in U.S. NHs. Understanding variations in practice is necessary to ensure that NH residents receive consistent, high-quality care in this setting.

Methods

A qualitative study was conducted. This study was a secondary data analysis of a larger study regarding infection control and prevention resources in NHs (R01NR013687), which is described in detail elsewhere.[156] Each NH was purposively selected with the goal of obtaining variation in geographical region, size, ownership status and 3-year infection control-related deficiency citation performance. The deficiency citation score is derived from infection control-related evaluation criteria found in annual, unscheduled inspections by the state that are required for Medicare and Medicaid certification and reimbursement (deficiency citations indicate poor performance).

NHs were recruited through informational mailings, follow-up phone calls and emails. At each facility, a site contact was identified who then recruited individual interviewees based on our guidelines for inclusion.[156] We aimed to recruit interviewees who were familiar with the facility based on tenure and who would provide a range of perspectives based on role (e.g., infection prevention directors, directors of nursing, assistant directors of nursing, medical directors, environmental service workers and staff nurses). Recruitment concluded when theoretical saturation across the entire NH sample was achieved for all infection control-related topics covered by the interview guides.[75]

Members of our study team (three male, five female) conducted in-depth, semi-structured interviews from May through September 2013. Each interviewee was interviewed once, one-on-one, with an interview guide informed by Donabedian's healthcare quality theoretical framework[63] and tailored for each personnel type.[156] All interviewers were trained on in-depth qualitative interviewing techniques and encouraged to manually record field notes regarding observations not captured in the interview.

Interviews were digitally recorded and transcribed verbatim. The Institutional Review Board of Columbia University Medical Center approved this study. All interviewees were informed of study goals and provided written informed consent.

A directed content analysis of all transcripts was performed (see Appendix H). This analytical technique helps to determine the initial coding scheme and is useful when existing theory or prior research insufficiently describes a particular phenomenon.[81] A keyword search of all transcripts was conducted in NVivo 10 (QSR International)[129] software using "isolation" and related terms (e.g., isolate, contact precaution, contact isolation, isolation precaution, cohort, quarantine, outbreak, cart, special precautions, single room, private room, signs, mask, gown, roommate) to highlight passages of text pertaining to the phenomena of interest. A keyword search is beneficial in content analysis when a large volume of text is available as it allows researchers to target passages with pertinent content to focus in-depth analysis.[144] Using Microsoft Excel[106] software to facilitate coding and analysis, CCC and MPM reviewed the extracted passages, generated a comprehensive set of primary and secondary codes and drafted definitions for each. Emerging themes were discussed weekly with all authors to ensure a shared understanding. The authors followed the Consolidated Criteria for Reporting Qualitative Research checklist in writing this manuscript (see Appendix I).[163]

Results

In total, 10 NHs were visited and 73 interviews were conducted, with 6-8 interviewees per facility. On average, interviews lasted approximately 45 minutes. Characteristics of the sample are described in detail elsewhere.[156] A total of 1533 references in 75 passages (representing 72 of 73 transcripts) were identified in the keyword search.

We found that isolation-based practices differed between NHs. The residents who received these interventions and the way they were implemented varied by facility. For example, some facilities automatically used isolation practices for residents with new respiratory or gastrointestinal symptoms, positive laboratory cultures and/or all residents admitted from a hospital setting. Other NHs rarely isolated residents. There was also variation with regard to whether isolation practices were discontinued based on laboratory cultures or upon resolution of symptoms. One exception to the variation between facilities existed: colonization (i.e., asymptomatic carriage) was not mentioned as a consideration for isolation

practices in any NH. Further, none of the interviewees reported routine screening of residents. As one interviewee stated, lack of routine surveillance was part of a "*don't look, don't tell*" approach to managing colonization (Participant 27: Medical Director, NH 4). Throughout the narratives we found that decision-making to use isolation practices was complex and this could be attributed to four emergent themes: (1) perceived risk of transmission; (2) conflict with quality of life goals; (3) resource availability; and (4) lack of understanding regarding infection prevention and control. Each of these themes are outlined in Figure 4.1 and described in-depth below.

Perceived Risk of Transmission

Interviewees discussed practice decisions in the context of organism transmission risk in specific situations and among individual residents. Most NHs' isolation practices incorporated the concept of organism 'containment', that is, low perceived transmission risk. This was a factor when staff decided the degree to which an infected resident would be limited in social and environmental contact.

> "*Anything that can be contained, like MRSA [*methicillin-resistant *Staphylococcus aureus],* or *VRE* [vancomycin-resistant enterococcus] *in a wound. Or if they have it in the urine, it's in a bag so it's contained. [...] so if it's contained, they can be cohorted.*" (Participant 57: Infection Prevention Director, NH 8)

There appeared to be variation regarding the emphasis on perceived organism containment, resident compliance, and surrounding residents' health when deciding to initiate or discontinue isolation-based practices and the nature of these practices. Additionally, the concept of effective containment varied, but generally applied to scenarios in which infectious secretions or drainage stayed within a colostomy bag or catheter, or were covered by personal protective equipment, a dressing or clothing. As one interviewee stated,

> "*If it was contained, [...] you didn't have to isolate [...] a catheter bag is closed… whereas if [there is …] no catheter, no coverage; then you know they're at risk."* (Participant 35: Minimum Data Set Coordinator, NH 5)

In contrast, interviewees mentioned *Clostridium difficile* most often as an example of an infection with high transmission risk because it is "*uncontrollable*" (Participant 17: Director of Nursing/ Infection Prevention Director, NH 3). A resident's ability and willingness to use appropriate personal hygiene,

standard precautions and potentially personal protective equipment outside of his/her room was also important. As explained by an administrator,

> "*If [a resident with diarrhea is] sharing the toilet with multiple people, then we [...] have to determine are they cognitively with it enough to know to use a bedside toilet? Or do we need to look at moving them to not risk contaminating the other residents?"* (Participant 47: Assistant Director of Nursing, NH 7)

Additionally, the overall health condition of a resident's existing roommate(s) was also a key factor in decision-making as explained below;

> *"We carefully monitor […] if [a resident is] placed on isolation, does their roommate have any open sores?"* (Participant 73: Infection Prevention Director, NH 10)

Variations in isolation-based practices included leaving a resident in a shared room, cohorting the infected resident with other infected resident(s) or transmission-based precautions in a private room. Additionally, practices varied as to whether an infected resident was allowed to leave his/her room, or was encouraged to participate in activities outside the room. As one interviewee stated,

> *"If [residents] are on isolation we do put an isolation gown on them and gloves, but they're free to come out of their room […] We try to get them to socialize, too.*" (Participant 41: Director of Nursing/ Infection Prevention Director, NH 6)

Interviewees in almost all facilities believed that isolation precautions were necessary when an infectious organism could not be contained or controlled, though this was not ideal.

Conflict with Quality of Life Goals

The importance of resident quality of life and concerns that isolation practices conflicted with resident quality of life was pervasive throughout the interviews. As explained by one administrator,

> *"If you have to isolate somebody or you have to put restrictions on them because of an infection [...] you have to balance the quality of life aspect."* (Participant 9: Administrator, NH 2)

When discussing this balance, interviewees regarded isolation as "*horrible*" (Participant 15: Administrator, NH 3). This is further described in the quotes below:

> *"We'd love to never have anybody on isolation."* (Participant 3: Quality Improvement Coordinator, NH 1)

"It's almost like holding a person prisoner." (Participant 47: Assistant Director of Nursing, NH 7)

However, interviewees felt that isolation-based practices are an important aspect of preventing and controlling infection. One administrator elaborated on this sentiment:

> *"We have a mission statement and the promise is to keep our residents safe and secure [...] that includes keeping them infection free as best as we can."* (Participant 1: Administrator, NH 1)

However, ways in which staff attempted to balance the NH environment as both a home and medical facility differed based on perceptions of resident needs. For example, at one facility socialization among residents was encouraged and the interviewee referred to isolation as allowing residents to leave their rooms while donning personal protective equipment (see the previous section); staff in another NH did not want to violate a resident's privacy by placing a sign on the resident's door, let alone encourage personal protective equipment use outside a private room. As an administrator explained,

> "*We do not put signs up [for isolation] because that's… considered a violation of their rights. So, you have [a] whole set of new issues in this home setting.*" (Participant 47: Assistant Director of Nursing, NH 7)

In this way, differences in perception of what maximizes quality of life led to variation in practice.

Resource Availability

Interviewees mentioned that the NH resources influenced isolation-based infection control practices; specifically, the availability of private rooms. For example,

> "*If it's [...] respiratory isolation, we can't handle that unless we can put them in a private room and usually our private rooms are full."* (Participant 24: Director of Nursing, NH 4)

It was advantageous, therefore, if a NH had all private rooms, as explained by one medical director,

> *"One good thing about this facility is that every room is a private room. [... the] need to isolate [an infected resident] from one resident or bulk of residents doesn't arise"* (Participant 20: Medical Director, NH 3)

The extent to which staff were pressed for time in daily practice was also a factor leading to variation as being "*in a hurry*" could result in forgetfulness or lack of awareness of appropriate isolation practices (Participant 43: Licensed Practical Nurse, NH 6). Having more time and other resources that enabled communication through multiple channels (e.g., email, formal in-person meetings, and/or headset

intercoms) raised awareness of recent infections and/or changes in practice and were facilitators to appropriate isolation practice. As described by an infection prevention director,

> "[*NH staff] can page me, they can stop me in the hallway. I receive phone calls at home with questions [...] it's very important to have that communication because they help me arrange private rooms, room changes."* (Participant 12: Infection Prevention Director, NH 2)

However, there was high variation across facilities in the modes of communication.

Lack of Understanding

In the majority of NHs, at least one interviewee offered information that conflicted with commonly accepted infection-related terminology. These statements may indicate a lack of understanding regarding key infection prevention and control concepts. Of note, three of those interviewees were in charge of infection prevention and control at his or her facility.

The terms isolation and cohorting were used inconsistently among interviewees. Isolation was used to refer both to processes to isolate organisms (e.g., personal protective equipment use by the resident outside of his/her room) as well as physically limiting interaction between residents and the surrounding environment. Isolation was used by some as an umbrella term that also encompassed the concept of cohorting. Interviewees used the term cohorting for various scenarios, some of which did not match the definition of cohorting given by the Centers for Disease Control and Prevention.[149] For example, one interviewee described placing healthy (low infection risk) residents with infectious residents as cohorting and referenced these same guidelines, as long as the non-infected roommate was "*alert*" and had no "*open orifices*" through which pathogens may be transferred (Participant 32: Director of Nursing, NH 5). Another discussed that cohorting might include placing residents with active infections caused by different drug-resistant organisms together in the same room provided that the infections of each were "*contained*" and the residents' provider(s) or families did not object to this action (Participant 41: Infection Prevention Director / Director of Nursing, NH 6).

For some interviewees, there were misunderstandings about bacterial colonization and the infection risk it poses. For example in discussing this topic, one interviewee stated that it is "*safe*" to place a methicillin-resistant *Staphylococcus aureus*-colonized resident with a roommate (Participant 50: Director

of Nursing, NH 7) and another stated that asymptomatic residents are "*not infectious*" (Participant 53: Administrator, NH 8).

Interviewees also noted fears of spreading infection not only among the residents but also to themselves, and to their families.

> "*We had someone that was just admitted not too long ago that had just a skin breakout [… staff members] were all very scared. They were gowning and gloving and masking to go in the room. But [the resident] wasn't infectious… we had to call another in-service and say look, [personal protective equipment] isn't needed."* (Participant 48: Assistant Director of Nursing/ Infection Prevention Director, NH 7)

Appropriate use of personal protective equipment was important to interviewees as observed inappropriate use during a mandatory annual state inspection of the facility may result in a deficiency citation and a costly fine. Interviewees noted that education might be key to alleviating fear of infection among staff as well as fear, frustration and intentional non-compliance among residents and their families in response to the resident's restricted location and/or activities.

Discussion

We inferred from these rich data that differences existed in isolation-based practices between facilities. This study confirmed that a lack of private rooms and other resources are barriers to isolation practices, as demonstrated in previous work.[90] We found that current practice to maintain a 'home-like' environment was informed by perceptions of transmission risk and resident quality of life. However, there were clear misunderstandings among some interviewees about current infection control terminology, recommendations and concepts.

Variation in practice between NHs was conspicuous and not surprising. According to clinical guidelines for this setting, contact precautions and other isolation-based infection prevention and control practices may be applied on a case by case basis to adapt practice to the needs of the individual facility and resident.[6] We infer from our data that these practices in NHs appear to be aligned with the clinical guidelines in this way. Our findings also suggest that variation is likely driven by a combination of factors including quality of life perception and prioritization, limited availability of private rooms, and lack of routine laboratory services and other resources. In particular, the desire among interviewees to balance

resident quality of life and infection prevention and control practices was striking and represents a specific challenge to infection reduction in this setting.[143] However, the degree to which NH staff are adjusting practice based on perception rather than evidence highlights ambiguity in published infection prevention and control guidelines and an overall lack of infection intervention effectiveness data specific to this setting.

A salient example of how care for residents may be improved with new evidence is greater understanding of transmission risk from residents colonized with MDROs in NHs. Contact precautions are not required for all MDRO carriers in this setting, but MDRO colonization should be a consideration for isolation when the risk is high that the resident will infect others.[6] Our interviewees either did not mention colonization in discussion of decision-making factors or stated specifically that their NH lacked colonization care protocols. This is consistent with a previous survey in which 36% of NH staff would not change their practices if they knew a resident was colonized or infected with methicillin-resistant *Staphylococcus aureus* or vancomycin-resistant enterococcus.[72] That survey did not provide data about why resident colonization status would not affect interviewee practices. While current guidelines advise NH staff to make isolation decisions on a case by case basis,[6; 148; 150], removing colonization status from the decision-making process entirely does not seem congruent with current clinical guidelines.[6; 148] Guidelines and the evidence supporting them should specifically address the relative transmission risk posed by certain residents and practices. The American Medical Directors Association, Society for Healthcare Epidemiology of America and Association for Professionals in Infection Control guidelines encourage covering draining wounds with dry dressings[6; 150] but the extent to which transmission risk is lower when secretions, colonization, or infection are contained under a dressing, within a device (i.e., urinary catheter drainage bag), or under clothing is not known.[130; 148; 149; 150] Further, limited evidence exists that the use of a bedside commode effectively reduces infection transmission risk when no private bathrooms are available.[54] The relative safety and benefits of allowing infected individuals to attend activities in shared spaces while donning personal protective equipment is not known. Therefore, practices based on perceived containment of the infection described here may not in fact be effective in preventing transmission of pathogens between residents. As mentioned above, isolation precautions have been primarily studied in acute care settings where the quality of data produced has been poor.[2; 59;

[93] More evidence regarding processes for precaution discontinuation as well as isolating residents when private rooms are not available (e.g., cohorting) would be beneficial for informed decision-making. This new evidence may help ensure consistent, high quality care for residents across NHs. Further, more standard, and perhaps simplified, guidelines may be warranted as new setting-specific evidence becomes available.

Given the inconsistent use of terminology and misunderstandings of infection concepts among NH staff, there may be a need to increase and/or reinforce understanding of existing guidelines. For example, although we cannot determine if interviewees' descriptions of cohorting an infected resident with a healthy resident in the same room represented an ineffective infection control practice, use of the term cohorting was inconsistent with the definition of cohorting provided in the Centers for Disease Control and Prevention guidelines (i.e., grouping together patients colonized or infected with the same organism by location during all activities to prevent organism transmission to unaffected patients).[149] It is doubtful that NH staff can apply the guidelines appropriately if the terminology is not understood. Inconsistent use of terminology and other misunderstandings revealed in these data may be due to the fact that infection prevention directors in this setting typically have minimal training for this role and multiple responsibilities.[156] However, training and education would presumably have a greater impact to reduce healthcare associated infections with the availability of new evidence regarding infection prevention and control practice effectiveness in this setting.

Limitations

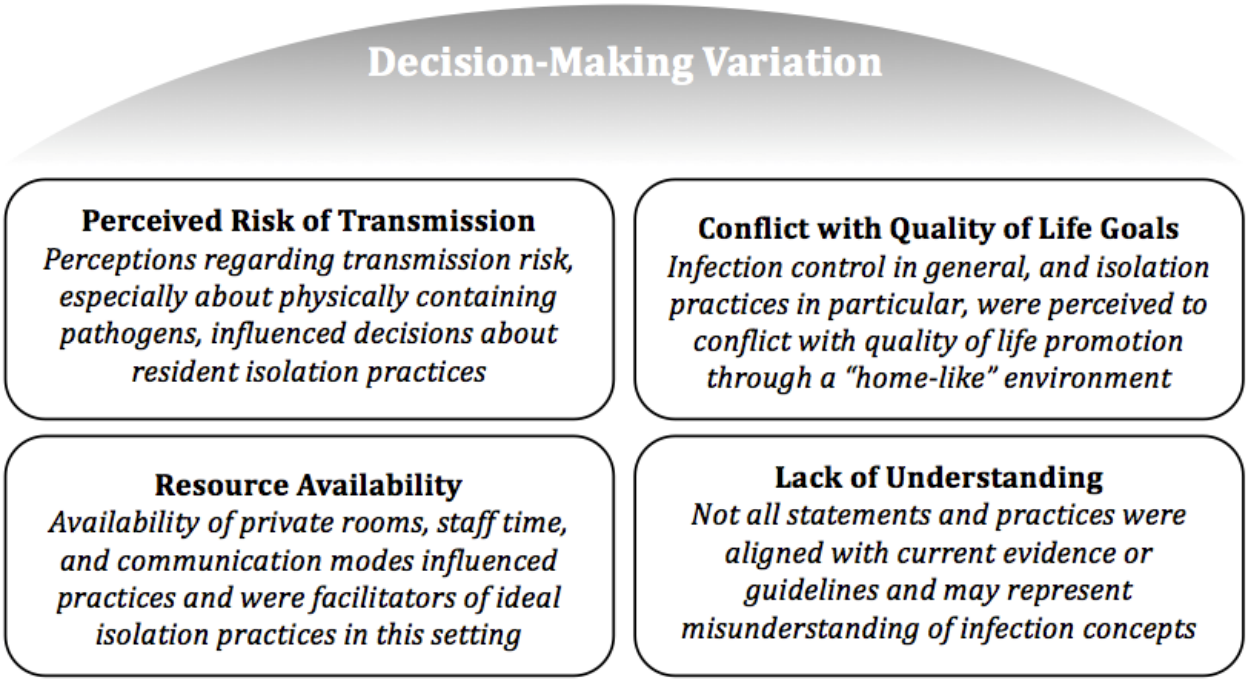
While our sample was purposefully geographically dispersed and sampled for diversity, high heterogeneity between NH facilities and resident populations[117] as well as state laws and initiatives[51] purposeful sampling may limit the transferability of study findings. Although these data represent U.S. NHs, themes may be more broadly applicable. As interviews were semi-structured to capture unanticipated and relevant content, there was variation in specific follow-up questions asked by each interviewer. Unless explicitly stated by the interviewee, we cannot conclude that certain decision-making factors, resources or practices were either present or absent at a particular NH, nor can we make conclusions about the relative importance of specific factors at a given facility or how frequently they were implemented. While we were not able to have each interviewee review transcripts, in an effort to conduct

member-checking, each NH was sent a summary of the findings from their facility and no corrections were offered. Use of a keyword search to identify passages of interest for our directed content analysis may have limited this study if a relevant passage was not identified. However, we are confident this was not the case as two randomly selected, full transcripts were reviewed to ensure the search results highlighted all relevant sections. The keyword search was therefore timesaving and helped to identify passages with content of interest.

Conclusion

There is wide variation in isolation-based infection prevention and control practices in NHs. Additional training may help staff better understand key infection prevention and control concepts and definitions. However, efforts to improve care in this setting should focus on generating new effectiveness research, which is necessary to understand which isolation-based infection prevention and control practices are associated with the lowest infection risk among NH residents. Results of those studies can better inform clinicians' decision-making regarding transmission risk and appropriate practices for individual residents, especially in cases of colonization, cohorting and other organism containment practices. New evidence on these topics is required to ensure high-quality, consistent care for this vulnerable population.

Figure 4.1: Emergent themes from qualitative directed content analysis regarding isolation-based infection control and prevention practices in nursing homes.



Chapter 5: Quantitative Analysis of Isolation Precautions Use

This chapter quantitatively describes isolation precaution use in nursing homes (NHs) for residents infected with a multidrug-resistant organism (MDRO). It adds to the literature, as this topic has not been studied to date using Minimum Data Set (MDS) data to the author's knowledge. This analysis examines extensive client and system characteristics that predict isolation precautions use.

Note: This manuscript has been prepared for submission to the *Journal of the American Geriatrics Society*.

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Abstract

BACKGROUND/OBJECTIVES: Nursing home (NH) residents contract an estimated 1.64 to 3.83 million infections annually. A growing number of these infections are the result of multidrug-resistant organisms (MDROs). While isolation precautions are widely recommended to control MDROs, NH isolation precaution use differs from acute care settings due to limited resources and conflicting care goals. To ensure high quality care of the vulnerable NH resident population, this study identifies client and system characteristics that predict use of isolation precautions against MDRO in NHs.

DESIGN: A cross-sectional analysis of a large, national dataset by multivariable linear probability models with facility-level fixed effects.

SETTING: All NHs certified to accept Centers for Medicare and Medicaid Services' (CMS) reimbursement October 2010-December 2013.

PARTICIPANTS: Elderly, long-stay residents of CMS-certified NHs with an MDRO-positive assessment.

MEASUREMENT: Data were obtained from: Minimum Data Set 3.0 (admissions, quarterly and annual assessments), Certification and Survey Provider Enhanced Reporting and Area Health Resource File. Multivariable models were generated to identify independent predictors of isolation use.

RESULTS: The sample included 191,816 assessments with an active MDRO infection, representing 138,294 unique residents in 11,773 NHs; of these, 12.8% recorded isolation precautions use. Of NHs reporting MDRO infection, 31% used isolation precautions to control MDRO. Clinical characteristics of individual residents that increased probability of isolation included needing support with activities of daily living (locomotion: +16.6%, $p < .001$, and eating: +6.1%, $p < .001$). Isolation was lower among those with a prior MDRO infection (-4.2%, $p< .001$) and wandering in the past 7 days. While registered nurse staffing was positively correlated with isolation precautions use, licensed practical nurse and certified nurse aide staffing was positively correlated with this practice at the highest and lowest levels. Residents in NHs that received an infection control-related citation in the past year had higher probability of isolation (+1.3%, $p = .02$); those in NHs that received a quality of care citation in the past year had a lower probability of isolation use (-2.2%, $p = .03$).

CONCLUSION: Isolation was used in only a small percentage of residents with positive MDRO assessment and there was variation across facilities as to whether isolation precautions were used for

MDRO infection. Within NHs that used isolation, staff treated MDRO-positive residents with a history of MDRO, wandering and higher eating and locomotion functionality differently than other MDRO-infected residents, perhaps to prioritize quality of life and preserve resident autonomy. The previous year's inspection also affected isolation precautions use, both through infection control-related citations and quality of care citations. While nursing staffing was also associated with precautions use, the relationships were unexpected and future research is needed to determine if staffing is a proxy for other system characteristics affecting treatment of MDRO infection.

KEYWORDS: Isolation precautions, infection prevention, nursing homes, large data analysis

Introduction

Antibiotic resistant bacteria are recognized as a serious threat by The Centers for Disease Control and Prevention (CDC)[32] and the World Health Organization.[175] Bacteria that are resistant to one or more classes of antibiotics represent a growing proportion of resistant infections. These multidrug resistant organisms (MDRO) are frequently resistant to almost all antimicrobial therapies.[148] While MDRO exist in many healthcare and community settings, these infections are a particular concern in nursing homes (NHs), where morbidity and mortality due to MDRO is especially high relative to other settings[150] and MDRO prevalence is increasing.[79]

Isolation precautions are a widely recommended practice to prevent MDRO infections.[6; 149; 150] The CDC describes isolation precautions to prevent transmission of pathogens by direct and indirect contact as 1) using standard precautions, 2) placing an infected individual in a private room, and 3) donning a gown and gloves when in close contact with the patient and the patient's environment.[149] Hereafter, these practices are referred to as isolation.

While isolation effectiveness for MDROs has been studied in acute care settings,[49; 57; 91; 119] isolation effectiveness in NHs is not well established[6] and may be impractical.[111] In NHs, an isolated resident "must remain in his/her room [which] requires that all services be brought to the resident (e.g. rehabilitation, activities, dining, etc.)".[37] Therefore, in addition to requiring a private isolation room, isolation also requires more resources than regular care such as dedicated personal care items, cutlery, commodes and more staff time to put on personal protective equipment when entering and leaving the room. The additional cost of isolation in long-term care is $6,000 per isolated resident annually,[20] which has been reported to influence isolation use.[90] Hence, isolation is often more difficult to implement in NHs as these facilities have fewer available resources. [168] Further, isolation is often in conflict with the NH goals of care to promote autonomy, function, dignity and comfort[171] and may therefore present an ethical dilemma.[156] As such, NH staff must decide to implement isolation precautions on a case-by-case basis[6; 149] to maximize resident quality of life while minimizing transmission risk to this vulnerable population as well as the cost of additional resources needed for isolation.[6]

Limited information exists about how NH staff attempt to reconcile infection control and prevention and other care goals,[19] but previous studies indicate that isolation use depends on the

individual resident.[52; 90] Resident characteristics that have been found to influence the decision to use isolation include not only the type of infection, but also the resident's personal hygiene, secretion control and infection location.[112] For example, those with an infection within an indwelling device or covered by a wound dressing might not be isolated.[6] Further, a resident's cognitive abilities to understand and comply with isolation practices may also be an important factor.[52] Residents with psychosocial or behavioral issues may be less likely to be isolated, as adverse psychosocial effects of these practices have been well documented.[13] Further, NH staff may be more likely to place new admissions on isolation as these individuals may not have a clear medical history.[88] Clinical practice guidelines acknowledge that the decision to use isolation precautions depends on the scenario, client (i.e., demographic and clinical) and system (i.e., facility and location) characteristics, but as many of these factors are perception-driven rather than evidence-based, substantial variation may exist in clinical practice.[52] Understanding how isolation is currently used in this setting is necessary to ensure high-quality care for this vulnerable population.

Objective

This study quantifies client and system characteristics that predict isolation among MDRO-infected residents of U.S. NHs using a national dataset. To our knowledge, a quantitative description of isolation in NHs across the nation has not been published in the scientific literature.

Methods

This study was a retrospective, cross-sectional analysis of 3 datasets obtained as part of a larger study (R01NR013687). Data were de-identified and new identification numbers were assigned to unique individuals prior to beginning this analysis. The Institutional Review Board of Columbia University Medical Center approved this study.

Data Sources

Data for this analysis were obtained from three national datasets: MDS 3.0, Certification and Survey Provider Enhanced Reporting (CASPER) and Area Health Resource File (AHRF). NH staff must complete detailed clinical MDS assessments for all residents as part of the Centers for Medicare and Medicaid Services (CMS) reimbursement eligibility criteria and quality assurance system. The MDS therefore captures detailed client characteristics from the residents in 96% of U.S. NHs.[27] Certified NHs

are required to have a registered nurse on staff to coordinate collection of MDS resident health status information and sign-off on each completed assessment. This study used information from admission, quarterly and annual MDS assessments from October 2010-December 2013; this date range limited data to the current version of the MDS (3.0).

The MDS 3.0 was designed to increase data quality and validity.[35] In a national evaluation study, the MDS variables used in this study all had very good or excellent reliability (measured as agreement among nurse researchers as well as between nurse researchers and facility nurses) with isolation having 100% agreement.[140]

Like MDS, CASPER is also a component of CMS's quality assurance system. Data contained in CASPER, referred to as Online Survey Certification and Reporting (OSCAR) prior to October 2010,[31] must be presented during the annual inspection and capture facility characteristics in the 2 weeks prior to inspection; submission of these data is required to obtain CMS reimbursement.[5] MDS assessments were linked by facility ID and most recent prior inspection date. Therefore, this study included data from 2009-2013, all of which are hereafter referred to as "CASPER".

Area Health Resource File (AHRF), referred to as Area Resource File prior to 2013, contributed data regarding the local environment in which the NHs operated in 2010-2013 AHRF is compiled by Health Resources and Services Administration from 50 databases containing county-level health status, facilities, professions, economic activities, and socioeconomic and environmental characteristics of geographic locations in the U.S.[166]

Study Sample

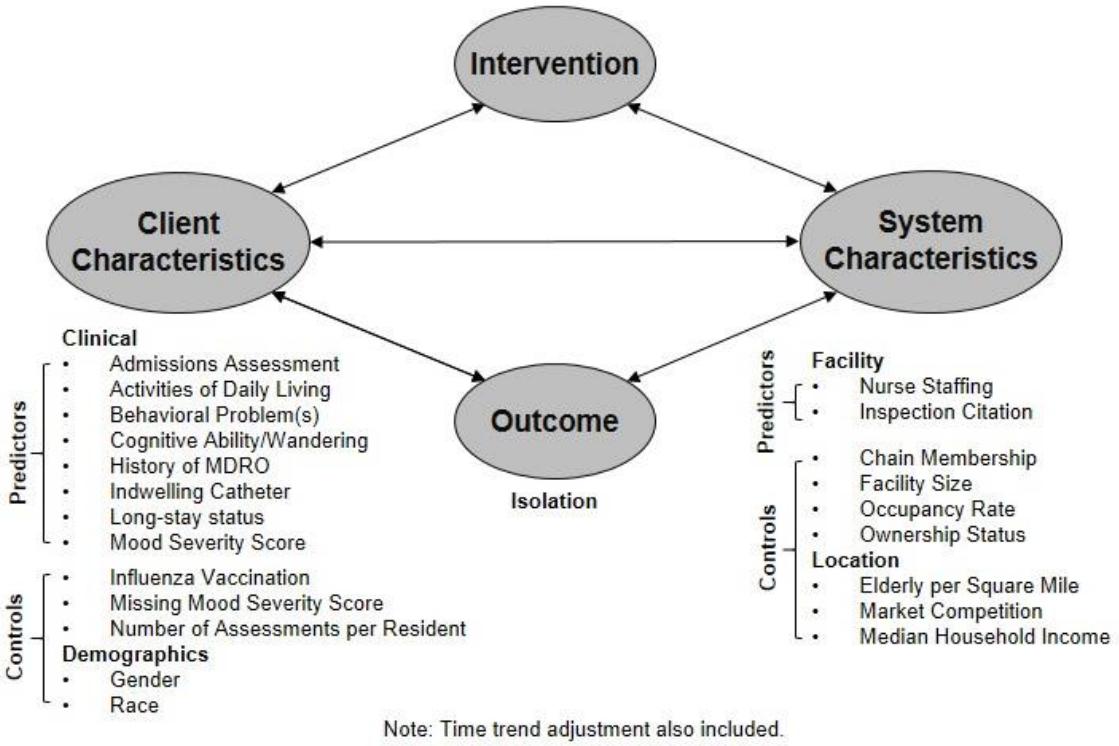
The sample was all MDRO-positive assessments of elderly residents (over 65 years of age). The sample was limited to assessments from NHs that were identifiable in both the MDS and CASPER data,[38] were freestanding and had 25 to 320 beds (98th percentile of facility size). These criteria eliminated hospital-based facilities, which have differing needs, susceptibility to infection[168] and cross-contamination risk[179] and also exceptionally small or large facilities, which have different infection control and prevention policies and resources.[179] Appendix J outlines the sampling process.

Variables

The dependent variable was isolation use as reported on the MDS. While isolation policies and practices appear to vary widely in NH,[150] the isolation precautions item in the MDS 3.0 specifically indicates that "the resident is in a room alone because of active infection". Residents reported to be in isolation must be individually isolated, not cohorted with others, even if potential roommates have the same disease.[39]

Figure 5.1 Concepts in linear probability model to predict isolation

(Among multidrug resistant organism (MDRO) infected nursing home residents, as organized by the Quality Health Outcomes conceptual framework)



Guided by the Quality Health Outcomes conceptual framework,[109] clinical guidelines[6; 149; 150] and previous research[52] empirical models were specified including client and system characteristics to predict isolation (see Figure 5.1). Client characteristics included admissions assessment, activities of daily living, behavioral problems,[52] history of MDRO infection, indwelling catheter use,[6] being a long stay resident (i.e., having stayed for greater than 100 days in the facility[138]) and mood. Resident cognitive ability (Alzhiemer's dementia, non-Alzheimer's dementia, ability to make self understood,[149] wandering[52]) was

also included to capture both contact with the environment and resident compliance ability. System characteristics identified as potential predictors of isolation use were: staffing levels of registered nurses, licensed practical nurses and certified nurse aides (measured as full time equivalents, FTE, hours per resident per day) and infection control-related and care quality deficiency citations on the last CMS inspection.[29]

Control variables included client demographics (i.e., gender, race), resident influenza vaccination,[6] time trend (assessment date), facility characteristics (number of beds, occupancy rate, chain membership, ownership status) and location characteristics. Control variables related to location included county demand for NH services (elderly per square mile), market competition (measured by the Herfindahl index which was calculated on a scale of 0-10,000, with 10,000 indicating complete market share of NH beds in the county[170]), and median household income. The number of assessments per resident was included to adjust for multiple measures of unique individuals and dummy variables were included to adjust for missing values of key predictors if these predictors were missing > 10% of values. Other variables with missing data (> 10%) were noted and removed. In addition to the above, seasonality (month), age, having an MDRO on the previous assessment and CMS region were assessed to describe the sample.

Data Analysis

Data were cleaned and continuous independent variables were standardized and categorized into deciles. Bivariate analyses were used to calculate standard descriptive statistics of all independent variables and the outcome. Description of the resident assessments included resident-level clustering and the description of NHs included facility-level clustering for robust standard errors, to account for repeated measures of unique individuals and facilities, respectively. Descriptors of NHs with and without isolation for MDRO infection in the past year were also compared.

Multivariable linear probability models were generated and fit-tested to specify a final model. A multivariable preliminary main effects model was developed to assess the functional forms of continuous variables and the outcome (see Appendix K) and specify each variable in the final model. Additionally, categorical dummy variables were jointly assessed; and, if clinically meaningful interaction terms were suspected, these were included if each either individually or jointly contributed to the model. While logistic

regression models may have been appropriate, use of those models was not possible given the size of the data set, number of variables, and available computational power. Further, as facility fixed effects were used to mitigate the effect of unobserved NH characteristics, a continuous outcome is preferred to avoid bias in the fixed effects estimate.[74] Adjusted R^2 was calculated for each model iteration and a C-statistic determined for the final model.

Robustness of final model results was tested by varying assumptions as follows: (A) changing the definition of a long-stay resident from >100 day stay to having an annual assessment, (B) excluding admissions assessments, (C) including non-elderly residents, (D) using state fixed effects and (E) using CMS region fixed effects. Each test was two-sided with alpha = .05. All analyses were conducted in Stata 13.[153]

Results

The data included 191,816 observations with an active MDRO infection, representing 138,294 unique residents in 11,773 NHs. Table 5.1 describes the total sample and assessments with and without isolation use. The sample represented residents that were predominantly female (59%) and non-Hispanic White (83.9%) with a mean age of 80.5 years. Of these MDRO-positive assessments, 12.8% reported isolation precautions. Of the NHs reporting an MDRO infection in the past year, 31% used isolation at least once for MDRO.

Demographics associated with isolation were younger age, male gender, Asian and Black race and Hispanic ethnicity (each $p < .001$). White race was inversely associated with isolation precautions ($p < .001$). Clinical characteristics associated with isolation precautions use in bivariate analyses were less independent activities of daily living (mean: 19.53 vs.18.58, $p < .001$), worse mood severity score (mean = 3.41 vs. 3.08, $p < .001$) and indwelling catheter use (26.5% vs. 20.92%, $p < .001$). Assessments showing isolation precautions were less likely to indicate behavioral problems (8.95% vs. 9.77%, $p < .001$), a dementia diagnosis (31.23% vs. 35.14%, $p < .001$), history of another MDRO-positive MDS assessment (15.08% vs. 29.78%, $p < .001$), current influenza vaccination (20.87% vs. 30.57%, $p < .001$), long-stay status (13.69% vs. 27.11%, $p < .001$), or wandering (1.24% vs. 2.07%, $p < .001$) (see Table 5.1). Isolation precautions use was also correlated with the date of assessment (both seasonality and time trend) as well as state and CMS region (each $p < .001$).

Table 5.2 compares NHs that used isolation precautions against MDRO in the past year to those that did not. Facilities using isolation were larger (124.34 vs. 113.83 beds, $p < .001$), more likely to be for-profit or government-owned, and more likely to have received an infection control-related citation (40.68% vs. 37.06%, $p < .001$) or care quality citation (68.10% vs. 66.21%, $p = .003$) on the last inspection. These facilities also had lower registered nurse staffing (0.70 vs. 0.71, $p = .007$), higher licensed practical nurse staffing (0.84 vs. 0.80, $p < .001$), lower occupancy rate (82.62% vs. 83.76%, $p < .001$) and were less likely to be members of a chain (58.61% vs. 62.33%, $p < .001$). NHs using isolation were located in less competitive markets (Herfindahl index =1802 vs. 2030, $p < .001$) and had more demand for nursing home services (elderly per square mile = 94.69 vs. 80.89, $p < .001$).

The final multivariable model had a C-statistic of .59, indicating fit greater than random chance[80] (see Table 5.3). Needing support with locomotion was associated with a 23.58% increase in probability of isolation ($p < .001$). Needing support with eating activities of daily living increased isolation probability by 17.92% ($p < .001$) and having an indwelling catheter increased isolation probability 8.24% ($p < .001$); use was also more likely to be recorded on assessment conducted for admission (48.07%, $p < .001$). Clinical characteristics associated with lower isolation probability were having a history of any MDRO-positive assessment before the current assessment (-14.34%, $p < .001$), needing support with bed mobility activities of daily living (-9.19%, $p = .01$), and wandering in the past 7 days. The full model output is available in Appendix L. While individual measures of dementia diagnoses and mood severity score were not significant, both groups of variables jointly contributed to the model (Appendix M).

NHs with 1.62-2.08 registered nurses FTE per resident per day were less likely to use isolation than those with 0.46-0.69 FTEs per resident per day. Both licensed practical nurses and certified nurse aide staffing were associated with lower probability of isolation with higher staffing. Further, MDRO-infected residents in NHs that received an infection control-related citation in the past year were associated with a 3.39% increased probability of isolation precautions use ($p = .02$), but were less likely to be on isolation precautions if the NH received a quality of care citation in the past year (-3.27%, $p = .03$).

The above results were robust with regard to (A) different definitions of long-stay residents and (C) with the inclusion of residents under age 65. Results were also robust when (B) the sample excluded admissions assessments, except for the characteristics of needing support with eating and RN staffing

level, which both became weaker positive predictors. Using state fixed effects (D) altered verbal behavioral problems and having an indwelling catheter were both stronger positive predictors. RN staffing became negatively associated with isolation use. Using CMS region fixed effects (E) changed these same predictors as the state fixed effects model and additionally altered having an MDRO history to be a stronger positive predictor and long-stay status to be a stronger negative predictor. Appendix N-Appendix P display significant changes to the output in each robustness check.

Discussion

This study provides novel, detailed understanding about nationwide isolation use in NHs. Not only were MDRO-infected residents rarely in isolation (12.8% of assessments), there was variation between NHs in the use of isolation at all. Only 31% of NHs with at least one MDRO-infected resident used isolation for MDRO in the calendar year. The low rate of isolation use for MDRO was surprising considering that 20% of all hospital inpatients are isolated at any given time.[58] This practice pattern warrants further investigation as to whether current use of isolation in NHs is effective to prevent MDRO transmission.

Most predictors of isolation in this analysis were aligned with expectations including recent admission, MDRO history and some activities of daily living. There was higher isolation use among recent admissions. Clinical history may be uncertain for recent admissions,[88] and some NHs may have policies to address transmission risk from new residents with pre-emptive isolation.[52] Lower isolation use among those with a prior MDRO infection (versus those with no MDRO history) may indicate that NH staff are concerned about resident quality of life among this population.[6] For example, if these residents had been isolated previously within or outside the facility, another isolation period would decrease the resident's quality of life. NH staff may also be trying to preserve resident psychosocial health and functionality by not using isolation as often for residents who needed support with eating and locomotion activities of daily living. These findings appear to match the priorities and perceptions of NH staff described in a previous qualitative study[52] and also would be expected if NH staff were following the American Medical Director's Association's (AMDA) infection control guidelines for long-term care that recommend considering resident quality of life, functionality and psychosocial health in the decision to use isolation.[6]

However, some associations between isolation and included variables were unexpected. First, hygiene-related activities of daily living were not associated with isolation. It is unclear why this may be the case as AMDA recommends poor hygiene and/or uncontrolled secretions as a consideration for whether to isolate that resident. Second, the relationship between isolation and having an indwelling catheter was surprising. While these data do not indicate whether the MDRO infection was in the catheter or elsewhere, the AMDA guidelines indicate that resident with infections within indwelling catheters may pose lower transmission risk, and therefore be less likely to need isolation precautions than those with an infection in another location. It is not clear why those with MDRO and an indwelling catheter would be more likely to be isolated.

Patterns of isolation use in NHs may be influenced by resources available in the facility to devote to isolation. For example, as nurses perceive isolation precautions as a time-intensive practice,[76] NH staff may be less likely to implement isolation among residents who require more frequent nursing care. This may explain the negative association between needing bed mobility support and isolation precautions use, as these elderly residents must be repositioned every 2 hours or less to avoid pressure ulcers (without a pressure-reducing device).[162] Further, there was an inverse relationship between wandering in the past 7 days and isolation precautions use, which may also be related to the perception that patients who wander may need more attention from nursing staff to ensure the resident stays in a private isolation room.[52] Moreover, residents who do not require support with eating activities of daily living (i.e., non-intubated) require the increased resource burden to the facility of disposable cutlery, plates and cups to use in isolation.[76] These additional resource requirements of isolation may explain the inverse relationship between independent eating activities and isolation. While it is not possible to determine from these data whether the additional resource burden to the NH influenced practice, it would be consistent with a previous survey in which 21.4% of NHs reported that they could not use isolation due to a lack of either dedicated equipment or a private room.[176]

These data imply that CMS inspections also affect infection control practices. NHs that received an infection control-related citation in the past year were more likely to use isolation precautions. This is not surprising given that limited infection prevention and control training[156] and knowledge deficits[52] have been identified among NH staff and NH staff who received an infection control-related citation in the past

year would have been recently informed of recommended practices. However, there was a negative relationship between receiving a quality of care citation in the past year and isolation. It is not clear why a quality of care citation would decrease use of isolation, but may indicate that the NHs receiving them have had to divert resources from infection control and prevention to improve other aspects of care. Nevertheless, additional infection prevention and control training for NH staff may be helpful to avoid citations[50] and decrease the inconsistency in isolation precaution use described here.

The influence of inspections on NH practice may also explain the relationships between isolation, wandering, and self-locomotion. An inverse relationship between wandering and isolation in the MDS may be because staff would not want to indicate an isolation protocol breach has taken place (i.e., the resident left the isolation room). Further, NH staff may be cautious to avoid using isolation among residents with higher risk of non-compliance (i.e., propensity to wander or ability to leave to room by independent self-locomotion) to avoid the financial penalties or increased regulatory oversight due to an inspection citation.[41] Needing locomotion assistance likely increases resident compliance with isolation as they may not be able to leave a private isolation room against protocol, easing the burden of maintaining compliance with isolation practice for NH staff.

Finally, as NH staffing levels have been previously associated with high care quality,[28] it was surprising that some higher levels of registered nurses, and higher licensed practical nurse and certified nurse aide staffing were associated with less isolation use compared to the highest staffing levels of each employee type. Within the facility fixed effects models, staffing levels within an individual facility may then act as a proxy for higher overall infection rates (i.e., at times with more temporary workers or infection outbreaks) and thereby when less available private rooms for each MDRO-infected resident. In a recent analysis, higher nurse staffing appeared to predict high infection rates.[67] Therefore, future studies should assess whether the facility-wide rate of MDRO and other infections are associated with isolation use.

Strengths and Limitations

Strengths of this study include the use of a large representative dataset that allowed for a comprehensive assessment of client and system predictors of isolation. Another strength of this study was the robustness of these findings when assumptions were modified. A limitation of the MDS is that assessments offer a snapshot of resident health with look-back periods that vary by the assessment item

(7-60 days).[131] The MDS does not include a measure of MDRO infection location or severity, which may influence isolation precaution use.[6] The sampling strategy based on individuals identified with positive MDRO infections may underrepresent the use of isolation for other organisms (e.g., *Clostridium difficile).* This may explain the moderate C-statistic for the final model. Nevertheless, this sampling strategy was thought to be adequate to determine how isolation precautions are used among MDRO-infected residents. These data do not include cohorting, other infection prevention and control practices or prevalence of infection in the NH for which isolation may be required. Use of other care practices may cause variation in the observed use of isolation precautions. Moreover, these data are retrospective and subject to self-reporting biases given that NH administrators compile and submit most collected data. However, MDS and CASPER data are subject to CMS audit and NH staff receive deficiency citations and penalties for inaccurate reporting.

Conclusions

This study is the first to examine predictors of NH isolation for MDRO, including detailed client and system characteristics in this large, national dataset. Here, we report that isolation is used in only a small percentage of residents with a positive MDRO assessment and there was variation in isolation for MDRO infection between facilities. Within NHs that use isolation, staff appear to be treating MDRO-positive residents with a history of MDRO, wandering and unsupported eating and locomotion activities of daily living differently than other MDRO-infected residents, perhaps to prioritize quality of life and preserve resident autonomy. It also appears that NH inspections are affecting isolation precautions use, both through infection control-related citations and quality of care citations. Future research is needed in this setting to determine if the use of isolation is effective to prevent MDRO infection and whether nurse staffing is a proxy for other system characteristics affecting treatment of MDRO infection.

Table 5.1 Characteristics of multidrug-resistant organism (MDRO) infected residents.

	All MDRO-Infected (N = 191,816)		Assessments with Isolation (n = 24,557)		Assessments without Isolation (n = 167,259)		
Resident Demographics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Age in years	80.46	8.50	79.79	8.39	80.56	8.51	< .001
	N	**%**	**N**	**%**	**N**	**%**	***P***
Female gender	113,321	59.08	14,020	57.09	99,301	59.37	< .001
Race							
American Indian or Alaskan Native	648	0.34	68	0.28	580	0.35	0.124
Asian	2,123	1.11	349	1.42	1,774	1.06	< .001
Black	16,456	8.58	2,524	10.28	13,932	8.33	< .001
Hispanic	7,028	3.66	1,269	5.17	5,759	3.44	< .001
Native Hawaiian/ Pacific Islander	478	0.25	56	0.23	431	0.26	0.409
White	160,993	83.93	19,775	80.83	141,218	84.43	< .001
Clinical Characteristics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Activities of daily living score *(0-28)*[a]	18.70	5.42	19.53	5.41	18.58	5.42	< 0.001
Mood severity score *(0-27)*[b]	3.13	3.88	3.41	4.10	3.08	3.85	< 0.001
	N	**%**	**N**	**%**	**N**	**%**	***P***
Behavioral problems	18,444	9.66	2,177	8.95	16,267	9.77	< 0.001
Dementia diagnosis	66,433	34.64	7,668	31.23	58,765	35.14	< 0.001
History of MDRO infection	53,505	27.90	3,704	15.08	49,801	29.78	< 0.001
Proximal MDRO infection *(within 6 weeks)*	465	0.24	75	0.31	390	0.23	0.071
Indwelling catheter	41,497	21.64	6,514	26.53	34,983	20.92	< 0.001
Influenza vaccination in current season	54,616	29.34	4,960	20.87	49,656	30.57	< 0.001
Long-stay status *(> 100 days in facility)*	48,708	25.39	3,361	13.69	45,347	27.11	< 0.001
Wandering	3,752	1.97	302	1.24	3,450	2.07	<0.001
Understood	136,157	71.31	17,011	69.86	119,146	71.52	<0.001
Other Predictors							
Time trend	--	--	--	--	--	--	< .001
Month of assessment *(seasonality)*	--	--	--	--	--	--	< .001
State	--	--	--	--	--	--	< .001
CMS region	--	--	--	--	--	--	< .001

Note: Representing 138,294 unique residents in 11,773 facilities. *P* values calculated by simple logistic regression with robust standard errors (resident-level clustering), significance level is alpha = .05; CMS = Centers for Medicare and Medicaid Services. [a]Self performance on all activities is zero on the activities of daily living support long-form score support long-form score and higher score indicates more support is needed. [b]Higher mood severity score represents worse condition.

Table 5.2 Characteristics of included facilities reporting at least one multidrug-resistant organism with comparison between facilities with and without reported isolation precaution use in the past year.

	All Facility Inspections (N = 31,759)		NHs with Isolation Precautions in Calendar Year (n = 9,969)		NHs without Isolation Precautions in Calendar Year (n = 21,790)		
Facility Characteristics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Facility size (number of beds)	117.13	50.11	124.34	51.87	113.83	48.92	< .001
Isolation precautions use	15.29%	29.16%	48.72%	32.88%			
Occupancy rate[a]	83.40%	13.61%	82.62%	13.47%	83.76%	13.66%	< .001
Staffing[b,c]							
Registered nurses	0.71	0.31	0.70	0.31	0.71	0.30	.007
Licensed practical nurses	0.81	0.31	0.84	0.32	0.80	0.30	< .001
Certified nurse aides	2.42	0.56	2.43	0.55	2.42	0.55	.218
	N	**%**	**N**	**%**	**N**	**%**	***P***
Chain membership	19,425	61.16	5,843	58.61	13,582	62.33	< .001
Citation on last inspection: *Infection control*	12,130	38.19	4,055	40.68	8,075	37.06	< .001
Citation on last inspection: *Care quality*	21,217	66.81	6,789	68.10	14,428	66.21	.003
Ownership status							< .001
For profit	23,732	74.73	7,686	77.10	16,046	73.64	
Government	1,205	3.79	401	4.02	804	3.69	
Not for-profit	6,822	21.48	1,882	18.88	4,940	22.67	
Location Characteristics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Elderly (65+ years) per square mile[b,d]	85.22	95.20	94.69	101.71	80.89	91.75	< .001
Market Competition[e]	1958	2516	1802	2387	2030	2569	< .001
Median household income[d]	$50,825	$12,608	$50,876	$12,552	$50,802	$12,633	.703
CMS region	--	--	--	--	--	--	< .001

Note: These data include annual inspections of NH with at least one MDRO infection, representing 138,294 unique residents in 11,773 unique facilities. MDRO = multidrug resistant organism; *P* values calculated by simple logistic regressions with robust standard errors (facility-level clustering), significance level 0.05; [a]Capped at 1 (100% occupancy). [b]Highest 1% of values excluded as outliers [c]Full time equivalent hour per resident per day; [d]In the county where the facility is located; [e]Herfindahl index calculated as 0-10,000, with 10,000 indicating complete market share of beds in the county and lower number indicate a more competitive market.

Table 5.3 Significant associations of multiple variable regression output

(with facility fixed effects)
Dependent variable: Isolation precautions reported on the current assessment
The final regression sample included 11,830 unique Nursing Homes, 188,059 observations.

Predictor	*Isolation Rate (%)*	*Change from Reference (%)*	*P*
Clinical Characteristics			
Activities of daily living: Bed mobility[a]			
Supervision needed	13.98%	-0.36%	.93
Support needed/activity did not occur	12.74%	-9.19%	.01
Activities of daily living: Eating[a]			
Supervision needed	12.20%	1.67%	.34
Support needed/activity did not occur	14.15%	17.92%	< .001
Activities of daily living: Locomotion[a]			
Supervision needed	10.98%	2.71%	.47
Support needed/activity did not occur	13.21%	23.58%	< .001
Admissions assessment	14.97%	48.07%	< .001
Dementia diagnosis, Alzheimer's[f]	12.70%	-1.24%	.68
Dementia diagnosis, not Alzheimer's[f]	13.42%	6.51%	.07
History of MDRO-positive MDS assessment			
(Before current assessment)	11.47%	-14.34%	< .001
Indwelling catheter	13.67%	8.24%	< .001
Mood Severity Score *(ref: 25-27)*[b,f]			
0-2	7.37%	-46.76%	.14
3-5	8.06%	-41.78%	.19
6-8	7.98%	-42.35%	.18
9-10	8.43%	-39.10%	.22
11-13	8.20%	-40.76%	.2
14-16	8.91%	-35.63%	.26
17-18	9.33%	-32.60%	.31
19-21	8.98%	-35.13%	.28
22-24	9.11%	-34.19%	.32
Wandering *(ref: no wandering)*			
1-3 days of last week	10.34%	-19.84%	< .001
4-6 days of last week	9.07%	-29.69%	< .001
Daily wandering in last week	10.78%	-16.43%	.02
Facility characteristics			
Citation on last inspection: *Infection Control*	13.12%	3.39%	.02
Citation on last inspection: *Care quality*	12.71%	-3.27%	.03
Staffing: Registered nurses[b,c,e]			
(ref: 0.46-0.69)			
0.00-0.23	13.9%	6.37%	.45
0.23-0.46	12.4%	-4.99%	.06
0.69-0.92	13.0%	-0.31%	.87
0.92-1.15	13.1%	0.61%	.84
1.15-1.39	12.7%	-2.84%	.51
1.39-1.62	13.4%	2.84%	.63
1.62-1.85	10.6%	-18.87%	.02
1.85-2.08	9.6%	-26.70%	.01

Predictor	*Isolation Rate (%)*	*Change from Reference (%)*	*P*
2.08-2.31	14.4%	10.13%	.45
Top 1% of RN staffing levels	4.81%	-0.31%	< .001
Predictor	***Isolation Rate at Mean***	***Change with 1 SD***	***P***
Staffing: Licensed practical nurse[b,c,e]	12.5%	-2.45%	.015[g]
Staffing: Certified nurse aide[b,c,e]	12.3%	-4.13%	.005[g]
Predictor	***Isolation Rate (%)***	***Change from Reference (%)***	***P***
Top 1% of LPN staffing levels	12.58%	-2.10%	.84
Top 1% of Aide staffing levels	15.02%	16.98%	.19
Interaction terms			
	12.40%		
Is understood and verbal behavior problems		-3.65%	.06
Dementia diagnosis and is understood	12.85%	0.00%	.99
Dementia diagnosis and hygiene ADLs	13.05%	4.90%	.29
Dementia diagnosis and eating ADLs	12.44%	-5.61%	< .001
Dementia diagnosis and toileting ADLs	13.13%	6.92%	.18
Dementia diagnosis and ADL dressing	12.20%	-14.21%	< .001
Market competition and elderly per square mile	43.43%	251.62%	.04
Market competition and median Income	8.28%	-37.09%	.57
Median income and elderly per square mile	-26.83%	-246.67%	.03

Note: Linear probability model with facility fixed effects (C-stat: .58, N = 188,059), SD = standard deviation. [a]Activities of daily living reference categories are "independent"; [b]Standardized and divided into 10 categories by value, with highest as the reference; [c]Highest 1% of values excluded as outliers; [d]Capped at 1 (100% occupancy); [e]Measured in full-time equivalent hours per resident per day; [f]Variables in group are jointly associated with the outcome, although no individual levels are. [g]P-value from joint contribution (F) test.

Chapter 6: Quantitative Analysis of Multidrug-Resistant Organism Infection Risk Factors

This chapter describes a study that evaluates which characteristics recorded on nursing home (NH) residents' previous Minimum Data Set (MDS) assessment predict multidrug-resistant organism (MDRO) infection on the current MDS assessment. Not only is it is the first study that uses a large, national data sample to examine predictors of MDRO infection in NHs, it examines extensive client and system characteristics as potential predictors.

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Abstract

Background: Reduction of multidrug-resistant organism (MDRO) infections in nursing homes (NHs) is a national priority. It is recommended that NH staff implement infection prevention interventions on a case-by-case basis. However, previous studies of MDRO risk factors have limited external validity. The objective of this study was to determine predictors of MDRO infection in U.S. NHs using a large, nationally representative dataset.

***Method*:** A longitudinal study was conducted using deidentified data from the Minimum Data Set, Certification and Survey Provider Enhanced Reporting and Area Health Resource File. A random 10% sample of NHs certified in 2010-2013 was selected. Assessments of elderly, long-stay residents within these NHs were included. Multivariable linear probability models with facility fixed effects were generated to identify predictors of MDRO infection recorded on the previous assessment.

Results: The sample contained 1,084,347 assessments (142,200 residents in 1,407 NHs). Of these, 0.68% recorded MDRO infection. Clinical characteristics associated with increased probability of MDRO infection were MDRO infection history (6502%, P < .001), dialysis (77% P < .001), antibiotics use (73%, *P* < .001), diabetes (51%, *P* < .001), locomotion support (9%, *P* = .02), indwelling devices and wounds. Dementia decreased the probability of MDRO. New residents had a 23% lower probability of having an MDRO infection (*P* = .03). Both certified nurse aide and licensed practical nurse staffing contributed to the model.

Conclusions: This comprehensive analysis confirms predictors of MDRO infection found in previous studies and adds new knowledge through inclusion of numerous, specific clinical and systems-based characteristics. Future research regarding registered nurse and licensed practical nurse staffing in preventing infection are needed to determine optimal staffing levels to reduce MDRO rates.

Background

Infections impose significant, but potentially preventable morbidity, mortality and costs on the vulnerable population residing in NHs, as well as the overall healthcare system.[150] Infection due to MDROs, such as methicillin-resistant *Staphylococcus aureus*, are a particular safety concern because NH residents are at high risk for these infections.[6] Moreover, MDRO infections are more costly to treat[26] and are associated with worse health outcomes in NHs than in other settings.[150] As the demand for NH care increases as the population of NH residents is expected to grow from 1.5 million today[168] to 5.3 million by 2030,[157] it is critical to optimize infection prevention and control practices in this setting.

NH staff must decide how to implement infection prevention and control practices balancing both transmission risk and resident quality of life in a setting with limited infection control resources.[105] These decisions may be challenging for staff when activities to reduce transmission risk (e.g., isolation precautions in a private room) conflict with other goals of care important to this setting (e.g., promoting socialization).[52] Infection prevention and control guidelines recognize that NH facilities vary in population acuity and resources (such as private room availability) and recommend that these practices be tailored to the resident population, the facility resources, as well as transmission risk to individual residents.[6] For example, some NH staff may place an MDRO-infected resident in the same room as a healthy resident considered to be low-risk for MDRO transmission.[52] However, the risk of MDRO transmission to the exposed roommate or other residents as a result of such decisions is unclear.

Current knowledge of MDRO infection predictors among NHs residents can be improved. In a study of antibiotic-resistant infection incidence and prevalence among NH residents, infection was associated with younger age, male gender, dialysis, paraplegia, quadriplegia, peripheral vascular disease, and diabetes mellitus as well as urinary catheterization, feeding tubes, tracheostomy, and use of intravenous medications.[136] However, not only are these data more than a decade old, but this analysis did not include facility characteristics, which given the high heterogeneity of NH resident and facilities,[117] limits the external validity of the findings. Moreover, interventions at the facility-level could be informed by understanding what system characteristics (i.e., facility and facility location characteristics) are associated with MDRO infection. Therefore, gaps in the literature exist in knowledge of current client and system characteristics that predict MDRO infection. As infections caused by MDROs have been rising in NHs,[79;

[111] NH staff must understand the predictors of MDRO infections among NH residents to reduce them in this setting.

Objective

The objective of this study was to determine the predictors of MDRO infection, including individual resident and system characteristics, in a nationally representative sample of U.S. NH residents.

Methods

We conducted a retrospective, longitudinal study using three large datasets: MDS, Certification and Survey Provider Enhanced Reporting (CASPER) and Area Health Resource File (AHRF). These data were obtained as part of the Prevention of Nosocomial Infections and Cost Effectiveness in Nursing Homes study (PNICE-NH, R01NR013687). Data were deidentified and new identification numbers were assigned to unique individuals prior to beginning this analysis. The Institutional Review Board of Columbia University Medical Center approved both PNICE-NH and this study.

NH staff must complete detailed clinical MDS assessments for all residents as part of the Centers for Medicare and Medicaid Services (CMS) reimbursement eligibility criteria and quality assurance system. The MDS therefore captures detailed client characteristics from the residents in 96% of U.S. NHs.[27] Certified NHs are required to have a registered nurse on staff to coordinate collection of MDS resident health status information and sign-off on each completed assessment. This study used information from admission, quarterly and annual MDS assessments from October 2010-December 2013; this date range limited data to the current version of the MDS (3.0). This version was designed to increase data quality and validity.[35] In a national evaluation study of the MDS, items included from the MDS for this study (discussed below) had either very good or excellent reliability among assessors. This included excellent agreement regarding “MRSA, VRE and Clostridium diff. infection/colonization” (kappa of .971) among nurse researchers and clinical nurses.[140]

Study Sample

Admissions, quarterly and annual MDS assessments were linked with CASPER data by CMS certification number and most recent prior inspection date. MDS and AHRF databases were linked by county and year. Data were cleaned and sampled (see Appendix Q).

The study included individual resident assessments from a sample of NHs identifiable in MDS and CASPER data. These NHs were freestanding (i.e., not hospital-affiliated) as residents in hospital-based facilities may have differing needs, susceptibility to infection[168] and cross-contamination risk.[179] NHs had between 25 and 320 beds (98th percentile) as exceptionally small or larger facilities may have different infection control and prevention policies and resources.[179] Of these eligible NHs, a 10% random sample was selected.

All resident assessments collected within the sample NHs were included in the analysis if they represented individual residents over 65 years of age who ultimately stayed for greater than 100 days.[138] Those who reside in NHs for less time are often admitted after acute care or for rehabilitation[37] and have different risk for infection[72] which justifies their exclusion. The final sample was all admissions, quarterly and annual MDS assessments of elderly, long-stay residents from the NH random sample.

Variables

The outcome was active MDRO infection recorded on the current MDS assessment (either a quarterly or annual). An MDRO-positive MDS assessment indicates that the infection 1) was diagnosed by an advanced healthcare provider in the past 60 days and 2) had "a direct relationship to the resident's current functional status, cognitive status, mood or behavior status, medical treatments, nursing monitoring, or risk of death" within the past 7 days.[40] Controls did not have an MDRO infection on the current assessment. Characteristics recorded on the previous assessment (admission, quarterly or annual) were compared to determine which predict MDRO infection.

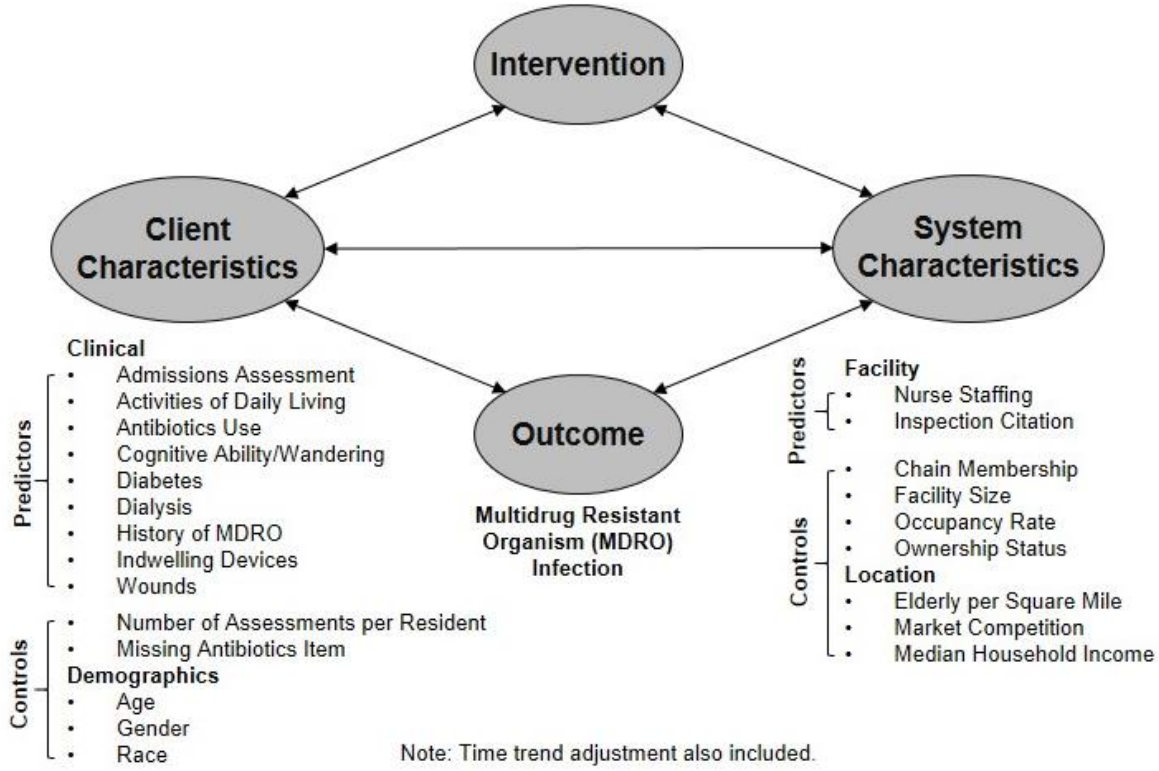
Specification of the empirical model was guided by the Quality Health Outcomes Model conceptual framework[109] and previous research[52] (see Figure 6.1). Clinical characteristics tested as predictors were whether the assessment was for admission, activities of daily living/functional status,[22] antibiotic exposure,[125; 168] cognitive ability[97] (dementia, wandering, making self understood), diabetes,[136] dialysis,[136] history of MDRO infection, indwelling devices[90; 136; 168] and wounds.[168] Facility predictors of MDRO infection were nurse staffing[101] (measured in staff full-time equivalents per resident per day, FTE) and inspection citations in the previous year. Client characteristic control variables were resident demographics (age, race, gender), and the total number of MDS assessments per resident (to avoid repeated measures bias). Other controls were facility characteristics (ownership status, facility size,[90]

chain membership, occupancy rate[29]) and facility location characteristics (market demand for NHs, market supply of NH beds, median income in the county[29]). Market competition was operationalized as the Herfindahl index (calculated as 0-10,000, with 10,000 indicating complete market share of beds in the county and lower number indicate a more competitive market[170]). Dummy variables were included to adjust for missing values of key predictors if these predictors were missing > 10% of values. Other variables more than 10% missing were noted and removed.

The assessment date was also included in analyses to assess time trends and seasonality (months) was also used to describe the sample. The State and CMS region were also used to describe these data to capture variation in public policy and initiatives at these levels to prevent HAI in NHs[51] (see Additional Appendix A).

Figure 6.1 Concepts in linear probability model to predict MDRO-infection among nursing home residents

(Organized by the Quality Health Outcomes conceptual framework)



Data Analysis

To avoid ecological fallacy,[145] that is deriving conclusions about individuals based on membership in a group, the analysis was conducted at the individual resident level. Data were cleaned and descriptive statistics were generated using bivariate analyses. Descriptive statistics of NHs with and without an MDRO infection in the past year were also compared. These analyses incorporated resident-level and facility-level clustering for robust standard errors to account for repeated measures of unique individuals and facilities, as appropriate.

Multivariable linear probability models were generated and fit-tested to determine a final model. Logistic regression was not possible given the size of the data set, number of variables, and available computational power. Further, as there are many potentially relevant NH characteristics, the final model was generated with facility-level fixed effects to mitigate the effect of unobserved characteristics (i.e.,

omitted variable bias). Hence, linear probability model were preferred to avoid biased fixed effects estimators characteristic of logistic regression.[74]

Continuous independent variables of interest were standardized and categorized into deciles. Functional forms of continuous variables were assessed in a preliminary main effects model to determine variable specification in the final model (see Appendix S). Categorical dummy variables were jointly assessed and if clinically meaningful interaction terms were suspected, they were included if each either individual or joint contributed to the model. The model adjusted for multiple measures of unique individuals by controlling for each resident's total number of assessments. An adjusted R^2 was calculated for each model iteration and a c-statistic was calculated for the final model.

Assumptions were varied in a number of ways to assess robustness of the conclusions. Descriptive statistics were assessed regarding A) characteristics associated with MDRO infection on the current assessment (rather than examining characteristics on the previous assessment). Robustness checks of the empirical model were conducted by changing the sample to exclude B) those without annual assessments rather than those staying <100 days, C) admissions assessments and D) residents with a current MDRO infection. Finally, robustness checks with fixed effects E) by state and F) CMS region were also conducted. Each test was two-sided with alpha = .05 and all analyses were conducted using Stata 13 statistical software.[153]

Results

The sample contained 1,084,347 observations, representing 142,200 residents in 1,407 NHs. Of observations which had a previous assessment from which predictors could be examined, there were 6,397 assessments with MDRO infection (0.68%) and 935,655 assessments without MDRO infection. The sample was 73% female and represented residents with a mean age of 83.6 years old (see Table 6.1). In bivariate analyses, assessment with MDRO infection were less likely to be female (64.45% vs. 73.02%, $P < .001$). Assessments with MDRO infection were more likely than those without MDRO infection to be a recent admission (12.49% vs. 8.19%, $P = .028$), receive dialysis in the facility (3.26% vs. 1.09%, $P = .028$), have a history of MDRO infection (32.56% vs. 0.44%, $P < .001$), have an indwelling catheter (29.31% vs. 8.47%, $P < .001$), or a wound (30.28% vs. 9.56%, $P < .001$). Assessments with MDRO infection were also less likely to have a dementia diagnosis (49.50% vs. 62.24%, $P = .002$).

The comparison of facilities that reported at least one MDRO infection in the previous calendar year to those without is presented in Table 6.2. Differences include that NHs with at least one MDRO infected resident were larger (mean: 121.88 vs. 99.39, $P < .001$) and had higher occupancy (mean: 84.12% vs. 80.35%, $P < .001$). NHs reporting at least one MDRO were in counties with greater elderly per square mile (mean: 88 vs. 72, $P < .001$), lower market competition (Herfindahl index mean: 2,004 vs. 2,327, $P < .001$) and higher median household income (mean: $53,075 vs. $50,976, $P < .001$).

The final multivariable linear probability model had a C-statistic of .78, indicating good fit[80] (see Table 6.3, Appendix T for complete output of the final model and Appendix U for the joint contributions of predictor concepts). Clinical characteristics that were associated with an increased probability of MDRO-positive clinical assessment were having a history of MDRO infection before the current assessment (+6502%, $P < .001$), receiving dialysis in the NH (+77% $P < .001$), receiving antibiotics in past 7 days (+73%, $P < .001$), needing support with locomotion activities of daily living (+9%, $P = .02$), and having an indwelling device (indwelling catheter, intermittent catheter, intravenous medication, ostomy, and tracheostomy) or a wound (pressure ulcer, venous-arterial ulcer, diabetic foot ulcer, surgical wounds and other open lesions). Diabetes diagnosis was associated with a 51% increase in the probability of MDRO infection ($P < .001$) and Alzheimer's dementia or non-Alzheimer's dementia decreased the probability of MDRO infection by 11% ($P < .001$) and 7% ($P = .01$), respectively. Residents new to the facility (following admissions assessment) had a 23% lower probability of having an MDRO-positive assessment ($P = .03$).

Certified nurse aide staffing significantly contributed to the model, but both higher and lower levels of staffing were associated with higher MDRO infection probability relative to median staffing. Conversely, the highest and lowest licensed practical nurses staffing were associated with higher rates of MDRO infection probability than the median level, but were not jointly significant. Registered nurse staffing was not associated with MDRO infection probability.

In the sensitivity analyses, describing the characteristics associated with MDRO on the current assessment (rather than from the previous assessment) removed bivariate associations between MDRO infection and a number of characteristics including needing support with activities of daily living (see Appendix R). However, the above results were robust when the sample was altered by changing the definition of long-stay residents (see Appendix V). When admissions assessments were excluded, results

were also robust except having a surgical wound(s), which became a stronger predictor of MDRO infection (see Appendix W). When residents with a current MDRO infection were excluded, antibiotics received, diabetes diagnosis, history of MDRO positive assessment and some indwelling devices (indwelling catheter, intermittent catheter, intravenous medications and tracheostomy) did not increase the probability of infection as much. Needing support with locomotion was no longer a predictor. However, some wounds increased probability of MDRO infection even more, including: diabetic foot ulcer, peripheral vascular ulcer, surgical wound, and other open lesions (see Appendix X). Using state and CMS region fixed effects did not alter these results except if the NH received an infection control-related citation in the last year (see Appendix Y and Appendix Z respectively).

Discussion

This study represents the most comprehensive assessment of MDRO infection predictors to date among the vulnerable population residing in NHs. It confirms concepts previously associated with MDRO or antibiotic resistant infection in smaller studies, such as positive correlations between MDRO infection and antibiotic use,[125; 168] diabetes, dialysis,[16; 136] and a previous MDRO-positive assessment.[113; 139] However, it also includes each of these variables in one model while adjusting for numerous clinical, facility, location and demographic characteristics, giving estimates of their independent affects.

This analysis has direct implications for clinical practice. Having an infected roommate or prior room occupant increases transmission risk.[48] Therefore, where private rooms are unavailable, MDRO-infection residents should not share a room with other resident(s) at increased risk for MDRO. In particular, they should not share a room with those who have an MDRO infection history, indwelling catheter, intermittent catheter, intravenous medication, ostomy, or tracheostomy, pressure ulcer, venous-arterial ulcer, diabetic foot ulcer, surgical wounds or other open lesions. Further, MDRO-infected residents should not share a room with those on dialysis, used antibiotics in the past 7 days, need support with locomotion, or have a diabetes diagnosis.

The results regarding hygiene activities of daily living, wandering and dementia diagnoses were surprising, and may be encouraging with regards to current practices. These characteristics may represent impairment of a residents' ability to follow recommended infection control and prevention practices, such as hand hygiene. Wandering and dementia may further represent the degree and type of

contact within this shared environment. Indeed, advanced dementia has been associated with MRSA colonization,[97] respiratory infections[128] and scabies cases[60] in previous studies. However, not only was needing support with hygiene activities of daily living or wandering in the past 7 days not a significant predictor in this analysis, a diagnosis of Alzheimer's or non-Alzheimer's dementia was associated with lower probability of MDRO infection. Current clinical guidelines advise NH staff to consider a resident's hygiene and self-care abilities for infection prevention activities.[6] The relationships of the aforementioned clinical characteristics and MDRO infection may indicate that NH staff are tailoring practice as recommended[6] to protect the more vulnerable NH residents from MDRO infection.

The associations between nurse staffing and MDRO infection probability was surprising and has implications for future research. In previous studies, certified nurse aide staffing was associated with NH care quality in general,[28] and MRSA risk among NH residents in particular.[97] Further, negative associations between NH infections and staffing were described, i.e., certified nurse aide staffing was directly associated whereas licensed practical nurse staffing was inversely associated.[180] As that analysis and this one adjusted for registered nurse staffing, it is possible that the NH facilities with low licensed practical nurse staffing have higher rates of registered nurse staffing and the higher skill level of the registered nurses may result in lower MDRO rates. On the other hand, lower staffing may be a proxy for another system characteristic that affects MDRO rates (e.g., staffing turnover or MDRO prevalence in the county). Future research is needed to clarify if nurses staffing is associated with MDRO and overall infection rates in NHs.

The rate of assessments with MDRO infection in this sample is low (0.68%) as it represents active MDRO infections within the 7-day look back period assessment collected roughly every 3 months. Therefore, these data do not offer a prevalence estimation. Of note, the proportion of MDRO positive assessments was different among the sample with a prior assessment from which to examine potential predictors (0.68% vs. 0.73%). While studies examining MDRO prevalence in NHs are frequently limited to a single facility, a study using the previous version of MDS (2.0) estimated that 1.27% of assessments indicated an antibiotic-resistant infection. This study included data from only 5 states and may have otherwise differed in sample criteria.[136] Therefore this study represents a more recent and nationally representative examination of MDRO infection in the MDS.

Strengths and Limitations

A strength of this study was the use of a large representative dataset that allowed for a detailed assessment of client and system characteristics as potential predictors of MDRO infection. A limitation of this analysis is that MDS and CASPER datasets do not include MDRO colonization, which may affect MDRO infection rates. Another limitation of the MDS is that assessments offer a snapshot of resident health with look-back periods that vary by item (7-30 days).[131] Limited assessment look-back periods limit potential accuracy of MDRO incidence determined through these data. Moreover, these data are retrospective and subject to self-reporting biases given that NH administrators compile and submit most collected data. However, MDS assessments are subject to CMS audit and NH staff receive deficiency citations and penalties for inaccurate reporting. Furthermore, CMS's reimbursement structure provides financial incentive for NHs to report as many infections as can be justified on these audits.[117]

In addition to use of large national data and numerous predictors, a strength of this analysis was the robustness checks. Pull potential predictors from the current rather than previous assessment removed a number of significant bivariate associations between MDRO infection and characteristics that may coincide with rather than predict MDRO infection (e.g., needing support with activities of daily living). Therefore, we can be confident that the outcome definition eliminates some associations that are not truly predictive. Similarly, when residents were excluded who had an MDRO infection on the previous assessment (i.e., the assessment from which clinical characteristics were examined), activities of daily living, receiving antibiotics and having a history of MDRO had weaker or no relationships with MDRO infection on the current assessment. This is not surprising as these factors likely change as a result of MDRO infection. Wounds and gender were also associated with greater increases in risk, which may represent intrinsic susceptibility to infection. When admissions assessments were excluded, it was not surprising that having a history of MDRO or a surgical wound were stronger predictors of MDRO infection. History of MDRO would be a stronger indicator of resident susceptibility to MDRO infection when the resident had not been recently exposed to a new environment and thereby new pathogens. Most surgical wounds would have healed by the time of a quarterly or annual assessment except those that are complicated (i.e., due to infection). Therefore, we are confident that these findings accurately represent predictors of MDRO infection among NH residents.

Conclusions

This analysis of a large, national dataset confirms many of the existing predictors regarding MDRO infection among NH residents and added new information about specific client and system characteristics. These results suggest that NH staff may be effectively tailoring practice to infection control and prevention needs of residents without self-care abilities (e.g., due to dementia). These findings may assist NH providers to further tailored infection prevention and control to the resident population in their NH facility. Future research regarding the relative roles of registered nurses, licensed practical nursed and certified nurse aide staffing in preventing infection may be useful to determine an optimal staffing level to reduce MDRO rates.

Table 6.1 Characteristics of resident assessments from random 10% sample of facilities.

P-values generated using simple logistic regression with resident-level clustered robust standard errors (significance level .05)

	All Assessments (N=1,084,347)		MDRO Infection On Next Assessment (n= 6,397)		No MDRO Infection On Next Assessment (n=935,655)		
Resident Demographics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Age in years	83.56	8.57	81.59	8.67	83.46	8.55	.132
	N	**%**	**N**	**%**	**N**	**%**	***P***
Female gender	788,084	72.68	4,123	64.45	683,181	73.02	< .001
Race							
American Indian or Alaskan Native	4,538	0.42	31	0.48	3,882	0.41	< .001
Asian	13,603	1.25	41	0.64	11,731	1.25	< .001
Black	119,049	10.98	530	8.29	103,542	11.07	.642
Hispanic	53,466	4.93	328	5.13	46,209	4.94	.819
Native Hawaiian/ Pacific Islander	2,631	0.24	17	0.27	2,251	0.24	.682
White	875,911	80.78	5,350	83.63	754,684	80.66	.534
Clinical Characteristic	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Activities of daily living support long-form score *(0-28)*[a]	16.88	7.17	18.83	6.10	16.69	7.20	.576
	N	**%**	**N**	**%**	**N**	**%**	***P***
Admissions assessment	77416	7.14	799	12.49	76610	8.19	.028
Antibiotic exposure	61502	12.74	847	31.50	48683	12.78	.537
Dementia diagnosis	677686	62.52	3164	49.50	582146	62.24	.002
Diabetes Mellitus diagnosis	346857	32.00	2837	44.36	297655	31.82	.183
Dialysis received in facility	12419	1.15	208	3.26	10112	1.09	< .001
History of MDRO infection	7742	0.71	2080	32.56	4133	0.44	< .001
Indwelling catheter	94676	8.73	1875	29.31	79259	8.47	< .001
Understood	583391	53.80	3759	58.76	509248	54.43	.547
Wandering in past 7 days	74475	6.88	201	3.15	65607	7.02	.387
Wounds	108630	10.02	1937	30.28	89465	9.56	.001
Other Predictors							
Quarter of assessment *(time trend)*	--	--	--	--	--	--	.225
Month of assessment *(seasonality)*	--	--	--	--	--	--	.581

Note: Represents 142,200 unique residents in 1,407 facilities. [a]Self performance on all activities is zero on the activities of daily living support long-form score and higher score indicates more support is needed. MDRO = multidrug resistant organism; SD = standard deviation; CMS = Centers for Medicare and Medicaid Services.

Table 6.2 Facility inspection descriptive statistics with comparison between facilities with and without reported MDRO infection in the past year.

	All Facility Inspections (N = 5,293)		NHs with MDRO Infection in Calendar Year (n = 2,080)		NHs without MDRO Infection in Calendar Year (n = 3,212)		
Facility Characteristics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Facility size (number of beds)	108.23	49.72	121.88	53.07	99.39	45.30	< .001
Occupancy rate[a]	81.83	15.08	84.12	12.93	80.35	16.16	< .001
Staffing[b,c]							
Registered nurses	0.65	0.30	0.68	0.28	0.64	0.31	< .001
Licensed practical nurses	0.79	0.31	0.80	0.29	0.79	0.32	.299
Certified nurse aides	2.39	0.64	2.38	0.60	2.40	0.67	.149
	N	**%**	**N**	**%**	**N**	**%**	***P***
Chain membership	3047	57.57	1265	60.82	1781	55.45	.812
Citation on last inspection:							
Infection Control	1948	36.80	767	36.88	1180	36.74	.029
Care quality	3565	67.35	1410	67.79	2154	67.06	.856
Ownership status							
For profit	3936	74.36	1552	74.62	2383	74.19	.982
Government	210	3.97	83	3.99	127	3.95	< .001
Not for-profit	1147	21.67	445	21.39	702	21.86	.779
Location Characteristics *(county-level)*	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***
Elderly (65+ years) per square mile[b]	78.42	97.14	88.04	100.75	72.20	94.23	< .001
Market Competition[d]	2,200	2,714	2,004	2,495	2,327	2,840	.002
Median household income	$51,802	$12,790	$53,075	$13,104	$50,976	$12,518	< .001

Note: Represents 1,407 unique facilities. MDRO = multidrug resistant organism; *P*-values calculated by simple logistic regressions with robust standard errors (facility-level clustering), significance level .05; [a]Capped at 1 (100% occupancy); [b]Highest 1% of values excluded as outliers; [c]Full time equivalent hour per resident per day; [d]Herfindahl index calculated as 0-10,000, with 10,000 indicating complete market share of beds in the county and lower number indicate a more competitive market.

Table 6.3 Predictors of multidrug-resistant organism infection in nursing homes

The regression included 1,404 unique facilities and 931,569 observations.

Predictor (recorded on previous assessment)	*MDRO Probability*	% Change in probability	*P*
Clinical Characteristics			
Activities of daily living: Locomotion[a]			
Support needed/activity did not occur	0.70%	9.38%	.02
Admissions assessment	0.53%	-23.08%	.03
Antibiotics Received *(in past 7 days or since admission/entry or reentry)*	1.13%	73.32%	< .001
Dementia diagnosis, Alzheimer's	0.62%	-11.49%	< .001
Dementia diagnosis, not Alzheimer's	0.66%	-7.09%	.01
Diabetes Mellitus diagnosis	0.88%	51.34%	< .001
Dialysis received in facility	1.19%	77.12%	< .001
History of MDRO-positive MDS assessment *(before current assessment)*	31.42%	6502.17%	< .001
Indwelling Devices			
Indwelling catheter	1.68%	165.55%	< .001
Intermittent catheter	1.69%	149.16%	< .001
Intravenous medication	2.81%	326.86%	< .001
Ostomy	1.07%	59.36%	< .001
Tracheostomy	2.10%	210.22%	< .001
Wounds			
Burn (of skin)	0.44%	-35.29%	.47
Diabetic foot ulcer	2.17%	222.30%	< .001
Non-diabetic open lesion on foot	0.96%	41.28%	.01
Pressure ulcer	1.40%	118.70%	< .001
Surgical wound	1.63%	146.39%	< .001
Venous-Arterial Ulcer	1.82%	174.62%	< .001
Open lesions other than ulcers, rashes and cuts	1.17%	74.40%	< .001
Facility Characteristics			
Staffing: Licensed practical nurse[b,c,d] *(ref: 0.61-0.82)*			
0.00-0.20	0.54%	-52.53%	.01
0.21-0.41	0.55%	-51.66%	.01
0.41-0.61	0.52%	-54.29%	.01
0.82-1.02	0.48%	-57.79%	< .001
1.02-1.23	0.50%	-56.04%	< .001
1.23-1.43	0.51%	-55.16%	< .001
1.44-1.64	0.42%	-63.04%	< .001
1.65-1.84	0.42%	-63.04%	< .001
1.85-2.05	0.31%	-72.67%	.01
Top 1% of LPN Staffing	0.86%	26.50%	.37
Staffing: Certified nurse aide[b,c,d] *(ref: 1.96-2.45)*			
0.00-0.48	0.91%	891.04%	.02
0.5-0.96	0.96%	945.37%	.01
0.99-1.47	0.80%	771.51%	.04
1.47-1.96	1.03%	1021.43%	.01
2.45-2.94	1.00%	988.83%	.01
2.95-3.43	1.20%	1206.16%	< .001
3.44-3.93	0.95%	934.50%	.04
3.93-4.41	0.85%	825.84%	.04
4.42-4.91	0.30%	228.19%	.7
Top 1% of CNA staffing	0.55%	-19.10%	.47

Predictor (recorded on previous assessment)	*MDRO Probability*	% Change in probability	*P*
Interaction terms			
Age and Diabetes Diagnosis	0.67%	-8.18%	< .001
Admissions Assessment and Income	1.49%	125.51%	< .001
Admissions Assessment and Elderly per Square Mile	0.46%	-32.17%	.08

Note: Output of linear probability model with facility fixed effects, C-statistic: .78. All categories of continuous variables are comprehensive within the final sample. [a]Activities of daily living reference categories are "independent"/"supervision needed"; [b] Continuous variables are standardized and divided into 10 categories by value, with highest as the reference; [c]Measured in full-time equivalent hours per resident per day; [d]Highest 1% of values excluded as outliers; [e]Standardized and divided into 5 categories by value, with highest as the reference.

Chapter 7: Synthesis

This final chapter synthesizes the results of studies presented in the preceding chapters of this dissertation. It discusses the implications of these results and makes recommendations for new health policy, clinical practice and future research. Finally, it reviews the strengths and limitations of this body of work.

Discussion

This dissertation represents the most comprehensive study of either multidrug-resistant organism (MDRO) infection predictors or isolation precautions use conducted in nursing homes (NHs) to date. To the author's knowledge, it is also the first to examine isolation precautions use in the Minimum Data Set (MDS) 3.0 data. A summary of each study's results is presented in Table 7.1.

The systematic review regarding isolation precautions effectiveness presented in this dissertation is aligned with literature published after this review was completed. Two systematic reviews regarding the effectiveness of contact isolation precautions for MDRO in acute care were published within months of this review's publication. One focused on Methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococcus (VRE) concluded that no strong evidence exists to support or reject use of this practice.[119] The other, which examined MRSA transmission and infection, concluded that contact precautions may be effective to reduce transmission in scenarios of epidemics and high compliance, but this practice had no affect on infection rates.[91] Additionally, a randomized control trial that would have been included in the review presented here had it been published at the time of the search indicated that contact isolation precautions were associated with less MRSA transmission but had no effect on VRE transmission. As such, these recent publications confirm there is mixed evidence for isolation precautions use for MDRO infection, as reported here.

While some new evidence is available regarding the cost of infection control activities in long-term care facilities, evidence needed for decision-making is still lacking.[83] A new brief report listed the additional cost of contact isolation precautions (including staff productivity and supplies) for MRSA colonization at $6,000 per isolated NH resident annually.[20] This report does not detail how cost estimations were derived, nor does it provide any information on the cost of alternative practices to prevent MRSA transmission in this facility. As such, it is in alignment with the findings of the systematic review that this body of literature can be improved.

Table 7.1 Summary of individual dissertation study findings

Aim	Chapter	Objective	Methods	Results Summary
1	2	To characterize the effectiveness of contact isolation precautions alone against transmission of any MDRO among adult acute care patients from interventional studies in which contact precautions are not bundled with other interventions	Systematic Review	• Six included studies examined four different MDRO outcomes • Five of six studies demonstrated no difference between isolation precautions and the control • Poor quality of evidence on this topic continues to limit interpretation of these data • Existing data did not constitute evidence for or against contact precautions
1	3	To identify and evaluate cost estimates reported in the scientific literature of structure and processes intended to prevent infection among residents and staff of LTCFs	Systematic Review	• Nine studies included represent diversity of study designs, health outcomes and cost measures • No meta-analysis or comparison of relative costs possible • Publications of low to moderate quality given lack of information regarding study methods, perhaps indicating low transparency rather than methodology sophistication • Insufficient evidence regarding infection prevention costs in long-term care to influence isolation precautions use in NHs
2	4	To qualitatively explore decision-making of NH staff regarding isolation-based infection prevention and control practices in this setting	Qualitative Directed Content Analysis	• Decision-making process to use isolation-based practices was complex and varied between NH • Differences in decisions due in part to available resources and staff perceptions of how to maximize resident quality of life • Quality of life perceived as in conflict with isolation precautions • Isolation use influenced by staff perceptions and understanding regarding containment (i.e., transmission risk) • Most practices were aligned with clinical guidelines to make decisions on a case by case basis • Variability in these data highlight the lack of evidence in this setting to tailor isolation decisions

Aim	Chapter	Objective	Methods	Results Summary
2	5	To quantify resident and facility characteristics that predict isolation precaution use among MDRO-infected residents of U.S. NHs using a national dataset	Multivariable linear probability model with facility fixed effects	• Isolation precautions not commonly used for MDRO (12.8%) • The majority of NHs with MDRO infections do not use isolation for MDRO at all (~70%) • Positive clinical predictor: locomotion support, eating support, indwelling catheter and admissions assessment, residing in a NH that received infection control-related citation(s) in past year • Negative clinical predictors: history of MDRO, bed mobility support, wandering and residing in NH that received quality of care citation(s) in past year • Results may indicate NH staff prioritization of resident quality of life and autonomy and scarcity of resources • Unexpected associations were RN, CNA and LPN nurse staffing • These variables may be proxies for resource availability or other NH characteristic(s) not captured in these data
3	6	To determine the predictors of MDRO infection, including individual resident and system characteristics, in a nationally representative sample of U.S. NH residents	Multivariable linear probability model with facility fixed effects	• 0.68% of assessments recorded active MDRO infection • Positive predictors: history of MDRO, antibiotics, locomotion support, wound(s), indwelling device(s), diabetes and LPN staffing in NH • Negative predictors: dementia diagnosis and admissions assessment, CNA staffing in NH • Predictors confirm associations from smaller studies and may indicate that prevention activities are tailored to the individual residents' needs

Note: MDRO = multidrug resistant organism; LTCFs = long-term care facilities; NHs = nursing homes; U.S. = United States; RN = Registered nurse; LPN = licensed practical nurse; CNA = certified nurse aide.

With the lack of effectiveness and cost data available with which to make isolation decisions, it was not surprising that variation exists in use of isolation precautions and other isolation-based infection prevention and control techniques in NHs. That being said, the extent to which isolation decisions by NH staff interviewees were influenced by perception, and occasionally misunderstanding, was concerning. Further, quantitative analysis confirmed that variation exists in isolation precaution use with approximately 70% of NHs with at least one MDRO infection did not use isolation precautions for MDRO at all for MDRO in the past year. While we cannot determine from these data if practice was inappropriate, the infrequent use of isolation for MDRO infection (12.8%), perception-based decision-making and inconsistent practice call into question the quality of care for all NH residents.

Nevertheless, results of these qualitative and quantitative studies suggest that NH staff adapt infection prevention and control practice of individual residents and NHs in three ways. First, NH staff appear to be emphasizing quality of life for NH residents in clinical practice. Second, practice may be influenced by availability of NH resources. Third, it appears that they are tailoring practice to individual residents' needs.

Quality of Life Prioritization

NH staff's prioritization of resident autonomy and quality of life was a strong theme in this work. In the qualitative interviews with NH staff, it was a prevailing theme for infection control and care decisions, which is consistent with previous studies.[65; 111] In the quantitative analysis, there was less isolation use among residents who needed support with eating or locomotion activities of daily living, or have had a prior MDRO infection. This pattern of use would be expected if NH staff wanted to promote resident autonomy and avoid repeated confinement, respectively. Such actions may preserve functionality, psychosocial health and thereby resident quality of life. Further, it has been suggested that long-term care residents with dementia perceive quality of life differently and may respond more negatively to isolation.[24] In this analysis, having dementia also affected isolation precaution use. Moreover, wandering in the past 7 days was negatively associated with isolation precautions. This may also indicate that NH staff were avoiding isolation precautions use to preserve quality of life for those they perceived would be most negatively affected by this practice. If so, these practice would be aligned with the recommendations of the American Medical Directors Association.[6]

Resource Constraints

NH resources may be an important consideration for isolation precautions use. NH staff were clear in the qualitative interviews that the availability of private rooms, among other resources, influenced isolation use. This was not unexpected as a previous survey of NH staff revealed that 42.2% of facilities that do not accept MRSA-colonized residents cannot do so because they lack private isolation room(s).[90] Resources such as staff productivity and supplies are also an important consideration for NH infection control practice.[76; 176] Moreover, the inverse relationships in this quantitative analysis between isolation precautions use and needing bed mobility support, wandering, and independent eating may also be explained by a desire to limit resource consumption. Residents with these characteristics likely require more frequent visits into the isolation room by staff and more disposable materials (e.g., plates, cutlery) needed for isolation precautions. Therefore, these data indicate that isolation precautions use may be influenced by the availability of NH resources.

Individualization of Infection Prevention

Infection prevention and control practices, especially isolation precautions, appear to be tailored to the needs of individual residents. Not only did NH staff recognize this as a goal in the qualitative analysis, the quantitative analyses indicate that residents who exhibit poor hygiene abilities, wandering and dementia were treated differently than other residents. As these clinical characteristics may affect transmission risk through self-care abilities and increased contact with the environment, the clinical guidelines recommend that NH staff consider transmission potential of the individual resident when implementing infection control and prevention practices. However, hygiene self-care abilities were not associated with MDRO infection, nor was wandering behavior. Dementia was inversely associated with MDRO infection. An explanation for this pattern could be that NH staff were giving enhanced attention to preventing transmission among residents with poor self-care practices and understanding of transmission risk, as is recommended.[6]

Clinical Practice Implications

This body of work has implications for on-going clinical practice in NHs. First, existing data should not be used as rationale to remove isolation precautions in the absence of further, more rigorous study. However, the MDRO infection predictors reported here, which are more specific than have previously been examined, may guide isolation precautions use. For example, in addition to confirming positive

association between MDRO infection and indwelling devices[108; 136] and wounds,[108; 168] this dissertation identified that some of the strongest clinical predictors of MDRO infection were specifically having an indwelling catheter, having pressure ulcer(s), receiving intravenous medication, having a surgical wound or a venous-arterial ulcer. Prior research primarily focused only on decubitus ulcers and wound management[25; 97; 137] rather than all wound types recorded in the MDS, excepting burns. Furthermore, while indwelling catheters have previously been identified as a risk for MDRO or antibiotic resistant infection in this population,[90; 97; 136; 137] MDRO risk due to intermittent catheters has rarely been explored and was identified here as a predictor of MDRO infection. The positive association between MDRO and physical functionality was also consistent with previous literature.[108; 136; 137] However, because a number of activities of daily living were included rather than a score or summation of these factors, this study provides specific information that "support with locomotion", but not other activities of daily living, predicts MDRO infection. The level of detail presented here may help direct decision-making around isolation precautions use in practice to avoid placing susceptible residents in close contact with MDRO-infected residents.

NH providers and administrators may wish to seek additional training in infection control. The qualitative interviews revealed misunderstandings of infection control and prevention concepts and terminology among many NH staff types, including administrators. While many of the statements made by interviewees may not necessarily represent poor practice, it is difficult to imagine high compliance and care improvement is possible if NH staff do not use terminology consistently with the clinical guidelines or with one another. The infrequent and inconsistent use of isolation precautions described here may also be the result of poor infection prevention and control training of NH staff. Regardless, training may benefit NH facilities as NHs in states with infection control and prevention training for long-term care settings have reduced infection control-related citations.[50]

Public Policy Implications

These data indicate that Centers for Medicare and Medicaid Services (CMS) inspections have an effect on NH practice, but raise concerns that NHs may not be able to simultaneously meet all requirements with existing resources. NH staff interviewed for this study were concerned about the financial implications of facility inspections (i.e., fines for deficiency citations). This dissertation's quantitative work confirmed isolation precaution use, a financially costly practice,[20] was more likely

following an inspection infection control-related citation. However, it also appears that receiving a quality of care citation in the past year decreases the use of isolation precautions. This may indicate that NHs staff were devoted additional resources to infection control and prevention practices when needed, but efforts were diverted to competing inspection priorities when needed. If this is the case, health policy devoting increased resources for infection prevention and control practices may be necessary to reduce MDRO in this setting without sacrificing quality of care in other areas.

The misinformation and inconsistent terminology stated by NH staff in the qualitative portion of this work supports potential change in policy to encourage or provide such training. Misunderstanding of appropriate isolation precautions use may explain the increased use of these practices following an inspection infection control-related citation. NH staff would need to review recommended infection prevention and control practices should they hope to avoid future citations, which may improve staff knowledge. If a lack of understanding of infection prevention and control practices or lack of familiarity with clinical guidelines is influencing practice, health policy to increase training and/or continued education may be useful.

However, staff training, NH inspections and resource allocation should be informed by evidence. These activities may be an inefficient use of facility, state and/or federal resources as well as NH staff time if isolation precautions are not effective. New effectiveness evidence is needed to inform practice, particularly regarding the relative effectiveness of various infection prevention and control practices. Therefore training should be a lower priority than generating the comparative and cost-effectiveness evidence needed to support decision-making in this setting.

Future Research

This body of work has identified a number of topics on which new evidence is needed to inform infection prevention and control practice in NHs: transmission risk from contained infections and MDRO colonization, efficacy of isolation precautions, and comparative effectiveness of isolation-based techniques. Although work presented here provides the most specific MDRO transmission risk factors among NH residents to date, NH staff should also be informed as to the transmission risk from residents with what might considered to be contained infections (i.e., under clothing or personal protective equipment, inside indwelling devices) as well as more evidence about risk from residents colonized with MDROs besides MRSA in this setting. Evidence may be improved through power calculation, compliance

monitoring, and non-equivalent concurrent controls when designing future studies. Further, integration of patient-centered outcomes (i.e., patient anxiety) is necessary to ensure the evidence has meaningful applications to the goals of care in this setting. Should isolation precautions be efficacious in this setting, then comparative and cost effectiveness research is needed to determine if isolation precautions are the best option to prevent infections in NHs. Future cost analysis studies may be improved by utilizing a health economic publication checklist.

Future studies of isolation precautions use and effectiveness in NHs should also consider prevalence of all infections that may require a private room. The prevalence of non-MDRO infections for which private rooms are required (e.g., *C. difficile*) would decrease the availability of private rooms for MDRO-infected residents. Private room availability and infection outbreaks in particular may be important variables to include in a future NH isolation precautions effectiveness study.

New evidence regarding NH nurse staffing levels is also needed as the relationships between MDRO infection as well as isolation precautions and some nurse staffing variables were unexpected. Based on these results, nurse staffing may be a proxy for other facility-level factor(s) that influence the MDRO infection rate and isolation precautions use. In particular, an intervention to increase CNA staffing to test affect on MDRO rates may be useful to inform new policy.

The only conflicting data between the studies that comprise this dissertation are around use of isolation precautions among residents with indwelling catheters. Interviewees in the qualitative study indicated that those with infections contained within an indwelling catheter (or otherwise contained) did not necessarily need isolation and were less likely to be isolated. While these perceptions were in alignment with clinical guidelines for long-term care,[6] the quantitative analysis of isolation precaution predictors identified that MDRO-infected residents with indwelling catheters were more likely to be isolated after adjusting for other characteristics. While MDS data does not indicate the site of the MDRO infection and the residents with MDRO infection and an indwelling catheter do not necessarily have MDRO infection within the catheter, this does not explain why residents with indwelling catheters would be more likely to be placed on isolation precautions. It is possible that indwelling catheters are a proxy for another client or system characteristics that were not captured in this analysis. All other findings appear to be consistent within this body of work.

Strengths and Limitations

Strengths of this dissertation include the multiple methods used to provide in-depth description of MDRO infection risk and isolation precautions use. The comprehensiveness of these quantitative studies in particular and large, national data adds new information to the scientific literature on these topics. Nonetheless, this body of work has limitations. This dissertation does not address scientific literature published in languages other than English or grey literature. The qualitative and quantitative studies are secondary data analyses, and therefore are limited by the transcripts and items that had previously been collected. None of the analyses account for the prevalence of other organisms for which isolation would be indicated or outbreaks in the NHs from which data were collected. Conclusions from the quantitative studies are further limited by study design and the nature of these data.

Conclusion

This dissertation provides new, specific evidence regarding MDRO infection risk, which can assist NH staff to tailor practice to the needs of individual NHs residents. Moreover, it demonstrates that while isolation precautions may be used in alignment with current clinical guidelines for this setting, isolation is used only occasionally and use is inconsistent between NHs. New comparative and cost effectiveness evidence regarding isolation-based practice specific to NHs is needed to further reduce practice inconsistency as well as costly and dangerous infections among this vulnerable population.

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List of Appendices

Appendix A MDS 3.0 Resident Assessment Form
(Select sections relevant to this study)

Resident _____ Identifier _____ Date _____

MINIMUM DATA SET (MDS) - Version 3.0
RESIDENT ASSESSMENT AND CARE SCREENING
Nursing Home Comprehensive (NC) Item Set

Section A Identification Information

A0050. Type of Record

Enter Code ☐

1. **Add new record** → Continue to A0100, Facility Provider Numbers
2. **Modify existing record** → Continue to A0100, Facility Provider Numbers
3. **Inactivate existing record** → Skip to X0150, Type of Provider

A0100. Facility Provider Numbers

A. **National Provider Identifier (NPI):** ☐☐☐☐☐☐☐☐☐☐

B. **CMS Certification Number (CCN):** ☐☐☐☐☐☐☐☐☐☐☐☐

C. **State Provider Number:** ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

A0200. Type of Provider

Enter Code ☐

Type of provider
1. **Nursing home (SNF/NF)**
2. **Swing Bed**

A0310. Type of Assessment

Enter Code ☐☐

A. **Federal OBRA Reason for Assessment**
01. **Admission** assessment (required by day 14)
02. **Quarterly** review assessment
03. **Annual** assessment
04. **Significant change in status** assessment
05. **Significant correction** to **prior comprehensive** assessment
06. **Significant correction** to **prior quarterly** assessment
99. **None of the above**

Enter Code ☐☐

B. **PPS Assessment**
PPS Scheduled Assessments for a Medicare Part A Stay
01. **5-day** scheduled assessment
02. **14-day** scheduled assessment
03. **30-day** scheduled assessment
04. **60-day** scheduled assessment
05. **90-day** scheduled assessment
06. **Readmission/return** assessment
PPS Unscheduled Assessments for a Medicare Part A Stay
07. **Unscheduled assessment used for PPS** (OMRA, significant or clinical change, or significant correction assessment)
Not PPS Assessment
99. **None of the above**

Enter Code ☐

C. **PPS Other Medicare Required Assessment - OMRA**
0. **No**
1. **Start of therapy** assessment
2. **End of therapy** assessment
3. **Both Start and End of therapy** assessment
4. **Change of therapy** assessment

Enter Code ☐

D. **Is this a Swing Bed clinical change assessment?** Complete only if A0200 = 2
0. **No**
1. **Yes**

A0310 continued on next page

Resident _____ Identifier _____ Date _____

Section A Identification Information

A0310. Type of Assessment - Continued

Enter Code ☐

E. Is this assessment the first assessment (OBRA, Scheduled PPS, or Discharge) **since the most recent admission/entry or reentry?**
0. **No**
1. **Yes**

Enter Code ☐☐

F. Entry/discharge reporting
01. **Entry** tracking record
10. **Discharge** assessment-**return not anticipated**
11. **Discharge** assessment-**return anticipated**
12. **Death in facility** tracking record
99. **None of the above**

Enter Code ☐

G. Type of discharge - Complete only if A0310F = 10 or 11
1. **Planned**
2. **Unplanned**

A0410. Submission Requirement

Enter Code ☐

1. **Neither federal nor state required submission**
2. **State but not federal required submission** (FOR NURSING HOMES ONLY)
3. **Federal required submission**

A0500. Legal Name of Resident

A. First name: ☐☐☐☐☐☐☐☐☐☐☐☐

B. Middle initial: ☐

C. Last name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

D. Suffix: ☐☐☐

A0600. Social Security and Medicare Numbers

A. Social Security Number: ☐☐☐ – ☐☐ – ☐☐☐☐

B. Medicare number (or comparable railroad insurance number):
☐☐☐☐☐☐☐☐☐☐☐☐

A0700. Medicaid Number - Enter "+" if pending, "N" if not a Medicaid recipient

☐☐☐☐☐☐☐☐☐☐☐☐☐☐

A0800. Gender

Enter Code ☐

1. **Male**
2. **Female**

A0900. Birth Date

☐☐ – ☐☐ – ☐☐☐☐
Month Day Year

A1000. Race/Ethnicity

↓ **Check all that apply**

☐ **A. American Indian or Alaska Native**

☐ **B. Asian**

☐ **C. Black or African American**

☐ **D. Hispanic or Latino**

☐ **E. Native Hawaiian or Other Pacific Islander**

☐ **F. White**

Resident _____ Identifier _____ Date _____

Section A Identification Information

A1100. Language

Enter Code ☐

A. Does the resident need or want an interpreter to communicate with a doctor or health care staff?
0. No
1. Yes → Specify in A1100B, Preferred language
9. Unable to determine

B. Preferred language:

A1200. Marital Status

Enter Code ☐

1. Never married
2. Married
3. Widowed
4. Separated
5. Divorced

A1300. Optional Resident Items

A. Medical record number:

B. Room number:

C. Name by which resident prefers to be addressed:

D. Lifetime occupation(s) - put "/" between two occupations:

A1500. Preadmission Screening and Resident Review (PASRR)

Complete only if A0310A = 01, 03, 04, or 05

Enter Code ☐

Is the resident currently considered by the state level II PASRR process to have serious mental illness and/or intellectual disability ("mental retardation" in federal regulation) or a related condition?
0. No → Skip to A1550, Conditions Related to ID/DD Status
1. Yes → Continue to A1510, Level II Preadmission Screening and Resident Review (PASRR) Conditions
9. Not a Medicaid-certified unit → Skip to A1550, Conditions Related to ID/DD Status

A1510. Level II Preadmission Screening and Resident Review (PASRR) Conditions

Complete only if A0310A = 01, 03, 04, or 05

Check all that apply

☐ A. Serious mental illness

☐ B. Intellectual Disability ("mental retardation" in federal regulation)

☐ C. Other related conditions

Resident _____ Identifier _____ Date _____

Section A Identification Information

A1550. Conditions Related to ID/DD Status

If the resident is 22 years of age or older, complete only if A0310A = 01

If the resident is 21 years of age or younger, complete only if A0310A = 01, 03, 04, or 05

Check all conditions that are related to ID/DD status that were manifested before age 22, and are likely to continue indefinitely

ID/DD With Organic Condition

- ☐ **A. Down syndrome**
- ☐ **B. Autism**
- ☐ **C. Epilepsy**
- ☐ **D. Other organic condition related to ID/DD**

ID/DD Without Organic Condition

- ☐ **E. ID/DD with no organic condition**

No ID/DD

- ☐ **Z. None of the above**

A1600. Entry Date (date of this admission/entry or reentry into the facility)

☐☐ – ☐☐ – ☐☐☐☐
Month Day Year

A1700. Type of Entry

Enter Code ☐

1. **Admission**
2. **Reentry**

A1800. Entered From

Enter Code ☐☐

01. **Community** (private home/apt., board/care, assisted living, group home)
02. **Another nursing home or swing bed**
03. **Acute hospital**
04. **Psychiatric hospital**
05. **Inpatient rehabilitation facility**
06. **ID/DD facility**
07. **Hospice**
09. **Long Term Care Hospital** (LTCH)
99. **Other**

A2000. Discharge Date

Complete only if A0310F = 10, 11, or 12

☐☐ – ☐☐ – ☐☐☐☐
Month Day Year

A2100. Discharge Status

Complete only if A0310F = 10, 11, or 12

Enter Code ☐☐

01. **Community** (private home/apt., board/care, assisted living, group home)
02. **Another nursing home or swing bed**
03. **Acute hospital**
04. **Psychiatric hospital**
05. **Inpatient rehabilitation facility**
06. **ID/DD facility**
07. **Hospice**
08. **Deceased**
09. **Long Term Care Hospital** (LTCH)
99. **Other**

Resident _____ Identifier _____ Date _____

Section A Identification Information

A2200. Previous Assessment Reference Date for Significant Correction
Complete only if A0310A = 05 or 06

Month – Day – Year

A2300. Assessment Reference Date

Observation end date:

Month – Day – Year

A2400. Medicare Stay

Enter Code

A. Has the resident had a Medicare-covered stay since the most recent entry?

0. **No** → Skip to B0100, Comatose
1. **Yes** → Continue to A2400B, Start date of most recent Medicare stay

B. Start date of most recent Medicare stay:

Month – Day – Year

C. End date of most recent Medicare stay - Enter dashes if stay is ongoing:

Month – Day – Year

Resident _____ Identifier _____ Date _____

Section G Functional Status

G0110. Activities of Daily Living (ADL) Assistance
Refer to the ADL flow chart in the RAI manual to facilitate accurate coding

Instructions for Rule of 3
- When an activity occurs three times at any one given level, code that level.
- When an activity occurs three times at multiple levels, code the most dependent, exceptions are total dependence (4), activity must require full assist every time, and activity did not occur (8), activity must not have occurred at all. Example, three times extensive assistance (3) and three times limited assistance (2), code extensive assistance (3).
- When an activity occurs at various levels, but not three times at any given level, apply the following:
  - When there is a combination of full staff performance, and extensive assistance, code extensive assistance.
  - When there is a combination of full staff performance, weight bearing assistance and/or non-weight bearing assistance code limited assistance (2).

If none of the above are met, code supervision.

1. ADL Self-Performance
Code for **resident's performance** over all shifts - not including setup. If the ADL activity occurred 3 or more times at various levels of assistance, code the most dependent - except for total dependence, which requires full staff performance every time

Coding:

Activity Occurred 3 or More Times
0. **Independent** - no help or staff oversight at any time
1. **Supervision** - oversight, encouragement or cueing
2. **Limited assistance** - resident highly involved in activity; staff provide guided maneuvering of limbs or other non-weight-bearing assistance
3. **Extensive assistance** - resident involved in activity, staff provide weight-bearing support
4. **Total dependence** - full staff performance every time during entire 7-day period

Activity Occurred 2 or Fewer Times
7. **Activity occurred only once or twice** - activity did occur but only once or twice
8. **Activity did not occur** - activity did not occur or family and/or non-facility staff provided care 100% of the time for that activity over the entire 7-day period

2. ADL Support Provided
Code for **most support provided** over all shifts; code regardless of resident's self-performance classification

Coding:
0. **No** setup or physical help from staff
1. **Setup** help only
2. **One** person physical assist
3. **Two+** persons physical assist
8. ADL activity itself **did not occur** or family and/or non-facility staff provided care 100% of the time for that activity over the entire 7-day period

	1. Self-Performance	2. Support
	Enter Codes in Boxes	
A. **Bed mobility** - how resident moves to and from lying position, turns side to side, and positions body while in bed or alternate sleep furniture	☐	☐
B. **Transfer** - how resident moves between surfaces including to or from: bed, chair, wheelchair, standing position (**excludes** to/from bath/toilet)	☐	☐
C. **Walk in room** - how resident walks between locations in his/her room	☐	☐
D. **Walk in corridor** - how resident walks in corridor on unit	☐	☐
E. **Locomotion on unit** - how resident moves between locations in his/her room and adjacent corridor on same floor. If in wheelchair, self-sufficiency once in chair	☐	☐
F. **Locomotion off unit** - how resident moves to and returns from off-unit locations (e.g., areas set aside for dining, activities or treatments). **If facility has only one floor**, how resident moves to and from distant areas on the floor. If in wheelchair, self-sufficiency once in chair	☐	☐
G. **Dressing** - how resident puts on, fastens and takes off all items of clothing, including donning/removing a prosthesis or TED hose. Dressing includes putting on and changing pajamas and housedresses	☐	☐
H. **Eating** - how resident eats and drinks, regardless of skill. Do not include eating/drinking during medication pass. Includes intake of nourishment by other means (e.g., tube feeding, total parenteral nutrition, IV fluids administered for nutrition or hydration)	☐	☐
I. **Toilet use** - how resident uses the toilet room, commode, bedpan, or urinal; transfers on/off toilet; cleanses self after elimination; changes pad; manages ostomy or catheter; and adjusts clothes. Do not include emptying of bedpan, urinal, bedside commode, catheter bag or ostomy bag	☐	☐
J. **Personal hygiene** - how resident maintains personal hygiene, including combing hair, brushing teeth, shaving, applying makeup, washing/drying face and hands (**excludes** baths and showers)	☐	☐

Resident _____ Identifier _____ Date _____

Section G Functional Status

G0120. Bathing

How resident takes full-body bath/shower, sponge bath, and transfers in/out of tub/shower (**excludes** washing of back and hair). Code for **most dependent** in self-performance and support

Enter Code ☐

A. Self-performance
0. **Independent** - no help provided
1. **Supervision** - oversight help only
2. **Physical help limited to transfer only**
3. **Physical help in part of bathing activity**
4. **Total dependence**
8. **Activity itself did not occur** or family and/or non-facility staff provided care 100% of the time for that activity over the entire 7-day period

Enter Code ☐

B. Support provided
(Bathing support codes are as defined in item **G0110 column 2, ADL Support Provided**, above)

G0300. Balance During Transitions and Walking

After observing the resident, **code the following walking and transition items for most dependent**

Coding:
0. **Steady at all times**
1. **Not steady, but able to stabilize without staff assistance**
2. **Not steady, only able to stabilize with staff assistance**
8. **Activity did not occur**

Enter Codes in Boxes

☐ **A. Moving from seated to standing position**

☐ **B. Walking** (with assistive device if used)

☐ **C. Turning around** and facing the opposite direction while walking

☐ **D. Moving on and off toilet**

☐ **E. Surface-to-surface transfer** (transfer between bed and chair or wheelchair)

G0400. Functional Limitation in Range of Motion

Code for limitation that interfered with daily functions or placed resident at risk of injury

Coding:
0. **No impairment**
1. **Impairment on one side**
2. **Impairment on both sides**

Enter Codes in Boxes

☐ **A. Upper extremity** (shoulder, elbow, wrist, hand)

☐ **B. Lower extremity** (hip, knee, ankle, foot)

G0600. Mobility Devices

Check all that were normally used

☐ **A. Cane/crutch**

☐ **B. Walker**

☐ **C. Wheelchair** (manual or electric)

☐ **D. Limb prosthesis**

☐ **Z. None of the above** were used

G0900. Functional Rehabilitation Potential

Complete only if A0310A = 01

Enter Code ☐

A. Resident believes he or she is capable of increased independence in at least some ADLs
0. **No**
1. **Yes**
9. **Unable to determine**

Enter Code ☐

B. Direct care staff believe resident is capable of increased independence in at least some ADLs
0. **No**
1. **Yes**

Resident _____ Identifier _____ Date _____

Section H Bladder and Bowel

H0100. Appliances

Check all that apply

- ☐ A. **Indwelling catheter** (including suprapubic catheter and nephrostomy tube)
- ☐ B. **External catheter**
- ☐ C. **Ostomy** (including urostomy, ileostomy, and colostomy)
- ☐ D. **Intermittent catheterization**
- ☐ Z. **None of the above**

H0200. Urinary Toileting Program

Enter Code ☐

A. **Has a trial of a toileting program (e.g., scheduled toileting, prompted voiding, or bladder training)** been attempted on admission/entry or reentry or since urinary incontinence was noted in this facility?
0. **No** → Skip to H0300, Urinary Continence
1. **Yes** → Continue to H0200B, Response
9. **Unable to determine** → Skip to H0200C, Current toileting program or trial

Enter Code ☐

B. **Response** - What was the resident's response to the trial program?
0. **No improvement**
1. **Decreased wetness**
2. **Completely dry** (continent)
9. **Unable to determine** or trial in progress

Enter Code ☐

C. **Current toileting program or trial** - Is a toileting program (e.g., scheduled toileting, prompted voiding, or bladder training) currently being used to manage the resident's urinary continence?
0. **No**
1. **Yes**

H0300. Urinary Continence

Enter Code ☐

Urinary continence - Select the one category that best describes the resident
0. **Always continent**
1. **Occasionally incontinent** (less than 7 episodes of incontinence)
2. **Frequently incontinent** (7 or more episodes of urinary incontinence, but at least one episode of continent voiding)
3. **Always incontinent** (no episodes of continent voiding)
9. **Not rated,** resident had a catheter (indwelling, condom), urinary ostomy, or no urine output for the entire 7 days

H0400. Bowel Continence

Enter Code ☐

Bowel continence - Select the one category that best describes the resident
0. **Always continent**
1. **Occasionally incontinent** (one episode of bowel incontinence)
2. **Frequently incontinent** (2 or more episodes of bowel incontinence, but at least one continent bowel movement)
3. **Always incontinent** (no episodes of continent bowel movements)
9. **Not rated,** resident had an ostomy or did not have a bowel movement for the entire 7 days

H0500. Bowel Toileting Program

Enter Code ☐

Is a toileting program currently being used to manage the resident's bowel continence?
0. **No**
1. **Yes**

H0600. Bowel Patterns

Enter Code ☐

Constipation present?
0. **No**
1. **Yes**

Resident _____ Identifier _____ Date _____

Section I Active Diagnoses

Active Diagnoses in the last 7 days - Check all that apply

Diagnoses listed in parentheses are provided as examples and should not be considered as all-inclusive lists

Cancer

- ☐ I0100. **Cancer** (with or without metastasis)

Heart/Circulation

- ☐ I0200. **Anemia** (e.g., aplastic, iron deficiency, pernicious, and sickle cell)
- ☐ I0300. **Atrial Fibrillation or Other Dysrhythmias** (e.g., bradycardias and tachycardias)
- ☐ I0400. **Coronary Artery Disease (CAD)** (e.g., angina, myocardial infarction, and atherosclerotic heart disease (ASHD))
- ☐ I0500. **Deep Venous Thrombosis (DVT), Pulmonary Embolus (PE), or Pulmonary Thrombo-Embolism (PTE)**
- ☐ I0600. **Heart Failure** (e.g., congestive heart failure (CHF) and pulmonary edema)
- ☐ I0700. **Hypertension**
- ☐ I0800. **Orthostatic Hypotension**
- ☐ I0900. **Peripheral Vascular Disease (PVD) or Peripheral Arterial Disease (PAD)**

Gastrointestinal

- ☐ I1100. **Cirrhosis**
- ☐ I1200. **Gastroesophageal Reflux Disease (GERD) or Ulcer** (e.g., esophageal, gastric, and peptic ulcers)
- ☐ I1300. **Ulcerative Colitis, Crohn's Disease, or Inflammatory Bowel Disease**

Genitourinary

- ☐ I1400. **Benign Prostatic Hyperplasia (BPH)**
- ☐ I1500. **Renal Insufficiency, Renal Failure, or End-Stage Renal Disease (ESRD)**
- ☐ I1550. **Neurogenic Bladder**
- ☐ I1650. **Obstructive Uropathy**

Infections

- ☐ I1700. **Multidrug-Resistant Organism (MDRO)**
- ☐ I2000. **Pneumonia**
- ☐ I2100. **Septicemia**
- ☐ I2200. **Tuberculosis**
- ☐ I2300. **Urinary Tract Infection (UTI) (LAST 30 DAYS)**
- ☐ I2400. **Viral Hepatitis** (e.g., Hepatitis A, B, C, D, and E)
- ☐ I2500. **Wound Infection** (other than foot)

Metabolic

- ☐ I2900. **Diabetes Mellitus (DM)** (e.g., diabetic retinopathy, nephropathy, and neuropathy)
- ☐ I3100. **Hyponatremia**
- ☐ I3200. **Hyperkalemia**
- ☐ I3300. **Hyperlipidemia** (e.g., hypercholesterolemia)
- ☐ I3400. **Thyroid Disorder** (e.g., hypothyroidism, hyperthyroidism, and Hashimoto's thyroiditis)

Musculoskeletal

- ☐ I3700. **Arthritis** (e.g., degenerative joint disease (DJD), osteoarthritis, and rheumatoid arthritis (RA))
- ☐ I3800. **Osteoporosis**
- ☐ I3900. **Hip Fracture** - any hip fracture that has a relationship to current status, treatments, monitoring (e.g., sub-capital fractures, and fractures of the trochanter and femoral neck)
- ☐ I4000. **Other Fracture**

Neurological

- ☐ I4200. **Alzheimer's Disease**
- ☐ I4300. **Aphasia**
- ☐ I4400. **Cerebral Palsy**
- ☐ I4500. **Cerebrovascular Accident (CVA), Transient Ischemic Attack (TIA), or Stroke**
- ☐ I4800. **Non-Alzheimer's Dementia** (e.g. Lewy body dementia, vascular or multi-infarct dementia; mixed dementia; frontotemporal dementia such as Pick's disease; and dementia related to stroke, Parkinson's or Creutzfeldt-Jakob diseases)

Neurological Diagnoses continued on next page

Resident _____ Identifier _____ Date _____

Section I Active Diagnoses

Active Diagnoses in the last 7 days - Check all that apply
Diagnoses listed in parentheses are provided as examples and should not be considered as all-inclusive lists

Neurological - Continued

- ☐ I4900. **Hemiplegia or Hemiparesis**
- ☐ I5000. **Paraplegia**
- ☐ I5100. **Quadriplegia**
- ☐ I5200. **Multiple Sclerosis (MS)**
- ☐ I5250. **Huntington's Disease**
- ☐ I5300. **Parkinson's Disease**
- ☐ I5350. **Tourette's Syndrome**
- ☐ I5400. **Seizure Disorder or Epilepsy**
- ☐ I5500. **Traumatic Brain Injury (TBI)**

Nutritional

- ☐ I5600. **Malnutrition** (protein or calorie) or at risk for malnutrition

Psychiatric/Mood Disorder

- ☐ I5700. **Anxiety Disorder**
- ☐ I5800. **Depression** (other than bipolar)
- ☐ I5900. **Manic Depression** (bipolar disease)
- ☐ I5950. **Psychotic Disorder** (other than schizophrenia)
- ☐ I6000. **Schizophrenia** (e.g., schizoaffective and schizophreniform disorders)
- ☐ I6100. **Post Traumatic Stress Disorder (PTSD)**

Pulmonary

- ☐ I6200. **Asthma, Chronic Obstructive Pulmonary Disease (COPD), or Chronic Lung Disease** (e.g., chronic bronchitis and restrictive lung diseases such as asbestosis)
- ☐ I6300. **Respiratory Failure**

Vision

- ☐ I6500. **Cataracts, Glaucoma, or Macular Degeneration**

None of Above

- ☐ I7900. **None of the above active diagnoses** within the last 7 days

Other

I8000. **Additional active diagnoses**
Enter diagnosis on line and ICD code in boxes. Include the decimal for the code in the appropriate box.

A.	_____	
B.	_____	
C.	_____	
D.	_____	
E.	_____	
F.	_____	
G.	_____	
H.	_____	
I.	_____	
J.	_____	

Resident _____ Identifier _____ Date _____

Section K Swallowing/Nutritional Status

K0100. Swallowing Disorder
Signs and symptoms of possible swallowing disorder

Check all that apply

- ☐ A. Loss of liquids/solids from mouth when eating or drinking
- ☐ B. Holding food in mouth/cheeks or residual food in mouth after meals
- ☐ C. Coughing or choking during meals or when swallowing medications
- ☐ D. Complaints of difficulty or pain with swallowing
- ☐ Z. None of the above

K0200. Height and Weight - While measuring, if the number is X.1 - X.4 round down; X.5 or greater round up

- ☐☐ inches — **A. Height** (in inches). Record most recent height measure since the most recent admission/entry or reentry
- ☐☐☐ pounds — **B. Weight** (in pounds). Base weight on most recent measure in last 30 days; measure weight consistently, according to standard facility practice (e.g., in a.m. after voiding, before meal, with shoes off, etc.)

K0300. Weight Loss

Enter Code ☐

Loss of 5% or more in the last month or loss of 10% or more in last 6 months
0. **No** or unknown
1. **Yes, on** physician-prescribed weight-loss regimen
2. **Yes, not on** physician-prescribed weight-loss regimen

K0310. Weight Gain

Enter Code ☐

Gain of 5% or more in the last month or gain of 10% or more in last 6 months
0. **No** or unknown
1. **Yes, on** physician-prescribed weight-gain regimen
2. **Yes, not on** physician-prescribed weight-gain regimen

K0510. Nutritional Approaches
Check all of the following nutritional approaches that were performed during the last **7 days**

1. **While NOT a Resident** Performed ***while NOT a resident*** of this facility and within the ***last 7 days***. Only check column 1 if resident entered (admission or reentry) IN THE LAST 7 DAYS. If resident last entered 7 or more days ago, leave column 1 blank
2. **While a Resident** Performed ***while a resident*** of this facility and within the ***last 7 days***

	1. While NOT a Resident	2. While a Resident
	Check all that apply	
A. **Parenteral/IV feeding**	☐	☐
B. **Feeding tube** - nasogastric or abdominal (PEG)	☐	☐
C. **Mechanically altered diet** - require change in texture of food or liquids (e.g., pureed food, thickened liquids)	☐	☐
D. **Therapeutic diet** (e.g., low salt, diabetic, low cholesterol)	☐	☐
Z. **None of the above**	☐	☐

K0700. Percent Intake by Artificial Route - Complete K0700 only if Column 1 and/or Column 2 are checked for K0510A and/or K0510B

Enter Code ☐

A. Proportion of total calories the resident received through parenteral or tube feeding
1. **25% or less**
2. **26-50%**
3. **51% or more**

Enter Code ☐

B. Average fluid intake per day by IV or tube feeding
1. **500 cc/day or less**
2. **501 cc/day or more**

Resident _____ Identifier _____ Date _____

Section M Skin Conditions

Report based on highest stage of existing ulcer(s) at its worst; do not "reverse" stage

M0100. Determination of Pressure Ulcer Risk

Check all that apply

- ☐ A. **Resident has a stage 1 or greater, a scar over bony prominence, or a non-removable dressing/device**
- ☐ B. **Formal assessment instrument/tool** (e.g., Braden, Norton, or other)
- ☐ C. **Clinical assessment**
- ☐ Z. **None of the above**

M0150. Risk of Pressure Ulcers

Enter Code ☐

Is this resident at risk of developing pressure ulcers?

0. **No**
1. **Yes**

M0210. Unhealed Pressure Ulcer(s)

Enter Code ☐

Does this resident have one or more unhealed pressure ulcer(s) at Stage 1 or higher?

0. **No** → Skip to M0900, Healed Pressure Ulcers
1. **Yes** → Continue to M0300, Current Number of Unhealed (non-epithelialized) Pressure Ulcers at Each Stage

M0300. Current Number of Unhealed (non-epithelialized) Pressure Ulcers at Each Stage

enter number ☐

A. Number of Stage 1 pressure ulcers

Stage 1: Intact skin with non-blanchable redness of a localized area usually over a bony prominence. Darkly pigmented skin may not have a visible blanching; in dark skin tones only it may appear with persistent blue or purple hues

B. Stage 2: Partial thickness loss of dermis presenting as a shallow open ulcer with a red or pink wound bed, without slough. May also present as an intact or open/ruptured blister

enter number ☐

1. **Number of Stage 2 pressure ulcers** - If 0 → Skip to M0300C, Stage 3

enter number ☐

2. **Number of these Stage 2 pressure ulcers that were present upon admission/entry or reentry** - enter how many were noted at the time of admission/entry or reentry

3. **Date of oldest Stage 2 pressure ulcer** - Enter dashes if date is unknown:

☐☐ – ☐☐ – ☐☐☐☐
Month Day Year

enter number ☐

C. Stage 3: Full thickness tissue loss. Subcutaneous fat may be visible but bone, tendon or muscle is not exposed. Slough may be present but does not obscure the depth of tissue loss. May include undermining and tunneling

1. **Number of Stage 3 pressure ulcers** - If 0 → Skip to M0300D, Stage 4

enter number ☐

2. **Number of these Stage 3 pressure ulcers that were present upon admission/entry or reentry** - enter how many were noted at the time of admission/entry or reentry

enter number ☐

D. Stage 4: Full thickness tissue loss with exposed bone, tendon or muscle. Slough or eschar may be present on some parts of the wound bed. Often includes undermining and tunneling

1. **Number of Stage 4 pressure ulcers** - If 0 → Skip to M0300E, Unstageable: Non-removable dressing

enter number ☐

2. **Number of these Stage 4 pressure ulcers that were present upon admission/entry or reentry** - enter how many were noted at the time of admission/entry or reentry

M0300 continued on next page

Resident _____ Identifier _____ Date _____

Section M Skin Conditions

M0300. Current Number of Unhealed (non-epithelialized) **Pressure Ulcers at Each Stage** - Continued

enter number

E. Unstageable - Non-removable dressing: Known but not stageable due to non-removable dressing/device

1. **Number of unstageable pressure ulcers due to non-removable dressing/device** - If 0 → Skip to M0300F, Unstageable: Slough and/or eschar

enter number

2. **Number of these unstageable pressure ulcers that were present upon admission/entry or reentry** - enter how many were noted at the time of admission/entry or reentry

enter number

F. Unstageable - Slough and/or eschar: Known but not stageable due to coverage of wound bed by slough and/or eschar

1. **Number of unstageable pressure ulcers due to coverage of wound bed by slough and/or eschar** - If 0→ Skip to M0300G, Unstageable: Deep tissue

enter number

2. **Number of these unstageable pressure ulcers that were present upon admission/entry or reentry** - enter how many were noted at the time of admission/entry or reentry

enter number

G. Unstageable - Deep tissue: Suspected deep tissue injury in evolution

1. **Number of unstageable pressure ulcers with suspected deep tissue injury in evolution** - If 0 → Skip to M0610, Dimension of Unhealed Stage 3 or 4 Pressure Ulcers or Eschar

enter number

2. **Number of these unstageable pressure ulcers that were present upon admission/entry or reentry** - enter how many were noted at the time of admission/entry or reentry

M0610. Dimensions of Unhealed Stage 3 or 4 Pressure Ulcers or Eschar
Complete only if M0300C1, M0300D1 or M0300F1 is greater than 0

If the resident has one or more unhealed (non-epithelialized) Stage 3 or 4 pressure ulcers or an unstageable pressure ulcer due to slough or eschar, identify the pressure ulcer with the largest surface area (length x width) and record in centimeters:

□□.□ cm

A. Pressure ulcer length: Longest length from head to toe

□□.□ cm

B. Pressure ulcer width: Widest width of the same pressure ulcer, side-to-side perpendicular (90-degree angle) to length

□□.□ cm

C. Pressure ulcer depth: Depth of the same pressure ulcer from the visible surface to the deepest area (if depth is unknown, enter a dash in each box)

M0700. Most Severe Tissue Type for Any Pressure Ulcer

Enter Code

Select the best description of the most severe type of tissue present in any pressure ulcer bed

1. **Epithelial tissue** - new skin growing in superficial ulcer. It can be light pink and shiny, even in persons with darkly pigmented skin
2. **Granulation tissue** - pink or red tissue with shiny, moist, granular appearance
3. **Slough** - yellow or white tissue that adheres to the ulcer bed in strings or thick clumps, or is mucinous
4. **Necrotic tissue (Eschar)** - black, brown, or tan tissue that adheres firmly to the wound bed or ulcer edges, may be softer or harder than surrounding skin

9. **None of the Above**

M0800. Worsening in Pressure Ulcer Status Since Prior Assessment (OBRA or Scheduled PPS) or Last Admission/Entry or Reentry
Complete only if A0310E = 0

Indicate the number of current pressure ulcers that were **not present or were at a lesser stage** on prior assessment (OBRA or scheduled PPS) or last entry. If no current pressure ulcer at a given stage, enter 0.

enter number

A. Stage 2

enter number

B. Stage 3

enter number

C. Stage 4

Resident _____ Identifier _____ Date _____

Section M Skin Conditions

M0900. Healed Pressure Ulcers

Complete only if A0310E = 0

Enter Code ☐ **A. Were pressure ulcers present on the prior assessment (OBRA or scheduled PPS)?**

0. **No** → Skip to M1030, Number of Venous and Arterial Ulcers
1. **Yes** → Continue to M0900B, Stage 2

Indicate the number of pressure ulcers that were noted on the prior assessment (OBRA or scheduled PPS) that have completely closed (resurfaced with epithelium). If no healed pressure ulcer at a given stage since the prior assessment (OBRA or scheduled PPS), enter 0.

enter number ☐ **B. Stage 2**

enter number ☐ **C. Stage 3**

enter number ☐ **D. Stage 4**

M1030. Number of Venous and Arterial Ulcers

enter number ☐ **Enter the total number of venous and arterial ulcers present**

M1040. Other Ulcers, Wounds and Skin Problems

Check all that apply

Foot Problems

☐ **A. Infection of the foot** (e.g., cellulitis, purulent drainage)

☐ **B. Diabetic foot ulcer(s)**

☐ **C. Other open lesion(s) on the foot**

Other Problems

☐ **D. Open lesion(s) other than ulcers, rashes, cuts** (e.g., cancer lesion)

☐ **E. Surgical wound(s)**

☐ **F. Burn(s)** (second or third degree)

☐ **G. Skin tear(s)**

☐ **H. Moisture Associated Skin Damage (MASD)** (i.e. incontinence (IAD), perspiration, drainage)

None of the Above

☐ **Z. None of the above** were present

M1200. Skin and Ulcer Treatments

Check all that apply

☐ **A. Pressure reducing device for chair**

☐ **B. Pressure reducing device for bed**

☐ **C. Turning/repositioning program**

☐ **D. Nutrition or hydration intervention** to manage skin problems

☐ **E. Pressure ulcer care**

☐ **F. Surgical wound care**

☐ **G. Application of nonsurgical dressings** (with or without topical medications) other than to feet

☐ **H. Applications of ointments/medications** other than to feet

☐ **I. Application of dressings to feet** (with or without topical medications)

☐ **Z. None of the above** were provided

Resident _____ Identifier _____ Date _____

Section N Medications

N0300. Injections

Enter Days ☐	**Record the number of days that injections of any type** were received during the last 7 days or since admission/entry or reentry if less than 7 days. If 0 → Skip to N0410, Medications Received

N0350. Insulin

Enter Days ☐	**A. Insulin injections - Record the number of days that insulin injections** were received during the last 7 days or since admission/entry or reentry if less than 7 days
Enter Days ☐	**B. Orders for insulin - Record the number of days the physician (or authorized assistant or practitioner) changed the resident's insulin orders** during the last 7 days or since admission/entry or reentry if less than 7 days

N0410. Medications Received

Indicate the number of DAYS the resident received the following medications during the last 7 days or since admission/entry or reentry if less than 7 days. Enter "0" if medication was not received by the resident during the last 7 days

Enter Days ☐	**A. Antipsychotic**
Enter Days ☐	**B. Antianxiety**
Enter Days ☐	**C. Antidepressant**
Enter Days ☐	**D. Hypnotic**
Enter Days ☐	**E. Anticoagulant** (warfarin, heparin, or low-molecular weight heparin)
Enter Days ☐	**F. Antibiotic**
Enter Days ☐	**G. Diuretic**

Resident _____ Identifier _____ Date _____

Section O Special Treatments, Procedures, and Programs

O0100. Special Treatments, Procedures, and Programs
Check all of the following treatments, procedures, and programs that were performed during the last **14 days**

1. **While NOT a Resident**
   Performed ***while NOT a resident*** of this facility and within the ***last 14 days***. Only check column 1 if resident entered (admission or reentry) IN THE LAST 14 DAYS. If resident last entered 14 or more days ago, leave column 1 blank
2. **While a Resident**
   Performed ***while a resident*** of this facility and within the ***last 14 days***

	1. While NOT a Resident	2. While a Resident
	↓ Check all that apply ↓	
Cancer Treatments		
A. Chemotherapy	☐	☐
B. Radiation	☐	☐
Respiratory Treatments		
C. Oxygen therapy	☐	☐
D. Suctioning	☐	☐
E. Tracheostomy care	☐	☐
F. Ventilator or respirator	☐	☐
G. BIPAP/CPAP	☐	☐
Other		
H. IV medications	☐	☐
I. Transfusions	☐	☐
J. Dialysis	☐	☐
K. Hospice care	☐	☐
L. Respite care		☐
M. Isolation or quarantine for active infectious disease (does not include standard body/fluid precautions)	☐	☐
None of the Above		
Z. None of the above	☐	☐

O0250. Influenza Vaccine - Refer to current version of RAI manual for current flu season and reporting period

Enter Code ☐

A. Did the **resident receive the influenza vaccine in this facility** for this year's influenza season?
0. **No** → Skip to O0250C, If influenza vaccine not received, state reason
1. **Yes** → Continue to O0250B, Date vaccine received

B. **Date vaccine received** → Complete date and skip to O0300A, Is the resident's Pneumococcal vaccination up to date?
☐☐ – ☐☐ – ☐☐☐☐
Month Day Year

Enter Code ☐

C. **If influenza vaccine not received, state reason:**
1. **Resident not in facility** during this year's flu season
2. **Received outside of this facility**
3. **Not eligible** - medical contraindication
4. **Offered and declined**
5. **Not offered**
6. **Inability to obtain vaccine** due to a declared shortage
9. **None of the above**

O0300. Pneumococcal Vaccine

Enter Code ☐

A. **Is the resident's Pneumococcal vaccination up to date?**
0. **No** → Continue to O0300B, If Pneumococcal vaccine not received, state reason
1. **Yes** → Skip to O0400, Therapies

Enter Code ☐

B. **If Pneumococcal vaccine not received, state reason:**
1. **Not eligible** - medical contraindication
2. **Offered and declined**
3. **Not offered**

Resident _____ Identifier _____ Date _____

Section O — Special Treatments, Procedures, and Programs

O0400. Therapies

A. Speech-Language Pathology and Audiology Services

Enter Number of Minutes

1. **Individual minutes** - record the total number of minutes this therapy was administered to the resident **individually** in the last 7 days

Enter Number of Minutes

2. **Concurrent minutes** - record the total number of minutes this therapy was administered to the resident **concurrently with one other resident** in the last 7 days

Enter Number of Minutes

3. **Group minutes** - record the total number of minutes this therapy was administered to the resident as **part of a group of residents** in the last 7 days

If the sum of individual, concurrent, and group minutes is zero, → skip to O0400A5, Therapy start date

Enter Number of Days

4. **Days** - record the **number of days** this therapy was administered for **at least 15 minutes** a day in the last 7 days

5. **Therapy start date** - record the date the most recent therapy regimen (since the most recent entry) started

Month – Day – Year

6. **Therapy end date** - record the date the most recent therapy regimen (since the most recent entry) ended - enter dashes if therapy is ongoing

Month – Day – Year

B. Occupational Therapy

Enter Number of Minutes

1. **Individual minutes** - record the total number of minutes this therapy was administered to the resident **individually** in the last 7 days

Enter Number of Minutes

2. **Concurrent minutes** - record the total number of minutes this therapy was administered to the resident **concurrently with one other resident** in the last 7 days

Enter Number of Minutes

3. **Group minutes** - record the total number of minutes this therapy was administered to the resident as **part of a group of residents** in the last 7 days

If the sum of individual, concurrent, and group minutes is zero, → skip to O0400B5, Therapy start date

Enter Number of Days

4. **Days** - record the **number of days** this therapy was administered for **at least 15 minutes** a day in the last 7 days

5. **Therapy start date** - record the date the most recent therapy regimen (since the most recent entry) started

Month – Day – Year

6. **Therapy end date** - record the date the most recent therapy regimen (since the most recent entry) ended - enter dashes if therapy is ongoing

Month – Day – Year

C. Physical Therapy

Enter Number of Minutes

1. **Individual minutes** - record the total number of minutes this therapy was administered to the resident **individually** in the last 7 days

Enter Number of Minutes

2. **Concurrent minutes** - record the total number of minutes this therapy was administered to the resident **concurrently with one other resident** in the last 7 days

Enter Number of Minutes

3. **Group minutes** - record the total number of minutes this therapy was administered to the resident as **part of a group of residents** in the last 7 days

If the sum of individual, concurrent, and group minutes is zero, → skip to O0400C5, Therapy start date

Enter Number of Days

4. **Days** - record the **number of days** this therapy was administered for **at least 15 minutes** a day in the last 7 days

5. **Therapy start date** - record the date the most recent therapy regimen (since the most recent entry) started

Month – Day – Year

6. **Therapy end date** - record the date the most recent therapy regimen (since the most recent entry) ended - enter dashes if therapy is ongoing

Month – Day – Year

O0400 continued on next page

Resident _____ Identifier _____ Date _____

Section O Special Treatments, Procedures, and Programs

O0400. Therapies - Continued

D. Respiratory Therapy

Enter Number of Minutes ☐☐☐☐

Enter Number of Days ☐

1. **Total minutes** - record the total number of minutes this therapy was administered to the resident in the last 7 days
   If zero, → skip to O0400E, Psychological Therapy
2. **Days** - record the **number of days** this therapy was administered for **at least 15 minutes** a day in the last 7 days

E. Psychological Therapy (by any licensed mental health professional)

Enter Number of Minutes ☐☐☐☐

Enter Number of Days ☐

1. **Total minutes** - record the total number of minutes this therapy was administered to the resident in the last 7 days
   If zero, → skip to O0400F, Recreational Therapy
2. **Days** - record the **number of days** this therapy was administered for **at least 15 minutes** a day in the last 7 days

F. Recreational Therapy (includes recreational and music therapy)

Enter Number of Minutes ☐☐☐☐

Enter Number of Days ☐

1. **Total minutes** - record the total number of minutes this therapy was administered to the resident in the last 7 days
   If zero, → skip to O0450, Resumption of Therapy
2. **Days** - record the **number of days** this therapy was administered for **at least 15 minutes** a day in the last 7 days

O0450. Resumption of Therapy - Complete only if A0310C = 2 or 3 and A0310F = 99

Enter Code ☐

A. Has a previous rehabilitation therapy regimen (speech, occupational, and/or physical therapy) ended, as reported on this End of Therapy OMRA, and has this regimen now resumed at exactly the same level for each discipline?

0. **No** → Skip to O0500, Restorative Nursing Programs
1. **Yes**

B. Date on which therapy regimen resumed:

☐☐ – ☐☐ – ☐☐☐☐
Month Day Year

O0500. Restorative Nursing Programs

Record the **number of days** each of the following restorative programs was performed (for at least 15 minutes a day) in the last 7 calendar days (enter 0 if none or less than 15 minutes daily)

Number of Days	Technique
☐	A. Range of motion (passive)
☐	B. Range of motion (active)
☐	C. Splint or brace assistance
Number of Days	**Training and Skill Practice in:**
☐	D. Bed mobility
☐	E. Transfer
☐	F. Walking
☐	G. Dressing and/or grooming
☐	H. Eating and/or swallowing
☐	I. Amputation/prostheses care
☐	J. Communication

Resident _____ Identifier _____ Date _____

Section O Special Treatments, Procedures, and Programs

O0600. Physician Examinations

Enter Days

Over the last 14 days, **on how many days did the physician (or authorized assistant or practitioner) examine the resident?**

O0700. Physician Orders

Enter Days

Over the last 14 days, **on how many days did the physician (or authorized assistant or practitioner) change the resident's orders?**

Section P Restraints

P0100. Physical Restraints

Physical restraints are any manual method or physical or mechanical device, material or equipment attached or adjacent to the resident's body that the individual cannot remove easily which restricts freedom of movement or normal access to one's body

Coding:
0. **Not used**
1. **Used less than daily**
2. **Used daily**

Enter Codes in Boxes	
	Used in Bed
☐	**A. Bed rail**
☐	**B. Trunk restraint**
☐	**C. Limb restraint**
☐	**D. Other**
	Used in Chair or Out of Bed
☐	**E. Trunk restraint**
☐	**F. Limb restraint**
☐	**G. Chair prevents rising**
☐	**H. Other**

Resident _____ Identifier _____ Date _____

Section V Care Area Assessment (CAA) Summary

V0200. CAAs and Care Planning

1. Check column A if Care Area is triggered.
2. For each triggered Care Area, indicate whether a new care plan, care plan revision, or continuation of current care plan is necessary to address the problem(s) identified in your assessment of the care area. The Care Planning Decision column must be completed within 7 days of completing the RAI (MDS and CAA(s)). Check column B if the triggered care area is addressed in the care plan.
3. Indicate in the Location and Date of CAA Documentation column where information related to the CAA can be found. CAA documentation should include information on the complicating factors, risks, and any referrals for this resident for this care area.

A. CAA Results

Care Area	A. Care Area Triggered	B. Care Planning Decision	Location and Date of CAA documentation
	↓ Check all that apply ↓		
01. Delirium	☐	☐	
02. Cognitive Loss/Dementia	☐	☐	
03. Visual Function	☐	☐	
04. Communication	☐	☐	
05. ADL Functional/Rehabilitation Potential	☐	☐	
06. Urinary Incontinence and Indwelling Catheter	☐	☐	
07. Psychosocial Well-Being	☐	☐	
08. Mood State	☐	☐	
09. Behavioral Symptoms	☐	☐	
10. Activities	☐	☐	
11. Falls	☐	☐	
12. Nutritional Status	☐	☐	
13. Feeding Tube	☐	☐	
14. Dehydration/Fluid Maintenance	☐	☐	
15. Dental Care	☐	☐	
16. Pressure Ulcer	☐	☐	
17. Psychotropic Drug Use	☐	☐	
18. Physical Restraints	☐	☐	
19. Pain	☐	☐	
20. Return to Community Referral	☐	☐	

B. Signature of RN Coordinator for CAA Process and Date Signed

1. Signature

2. Date ☐☐ – ☐☐ – ☐☐☐☐ (Month – Day – Year)

C. Signature of Person Completing Care Plan Decision and Date Signed

1. Signature

2. Date ☐☐ – ☐☐ – ☐☐☐☐ (Month – Day – Year)

Appendix B Preferred Reporting Items for Systematic Reviews and Meta-Analyses Statement

Section/Topic	#	Checklist Item	Reported on Page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	
Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome-level assessment (see Item 12).	
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group and (b) effect estimates and confidence intervals, ideally with a forest plot.	
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., health care providers, users, and policy makers).	
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review level (e.g., incomplete retrieval of identified research, reporting bias).	
Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	

Appendix C A complete search strategy regarding isolation precautions and multidrug-resistant organisms within the PubMed electronic database

	Search Terms (combined with "AND")
Concept 1: Isolation	((((((isolation precaution[Title/Abstract]) OR isolation precautions[Title/Abstract]) OR barrier precaution[Title/Abstract]) OR barrier precautions[Title/Abstract]) OR contact precaution[Title/Abstract]) OR contact precautions[Title/Abstract]) OR contact isolation[Title/Abstract]
Concept 2: Multiple drug resistance	(("drug resistance, multiple"[MeSH Terms] OR ("drug"[All Fields] AND "resistance"[All Fields] AND "multiple"[All Fields]) OR "multiple drug resistance"[All Fields] OR ("multiple"[All Fields] AND "drug"[All Fields] AND "resistance"[All Fields])) OR ("cross infection"[MeSH Terms] OR ("cross"[All Fields] AND "infection"[All Fields]) OR "cross infection"[All Fields]))
Concept 3: Bacteria/Infection	((((((((((((((("infections"[All Fields] AND "bacteria"[All Fields])) OR ("infection"[All Fields] AND "bacteria"[All Fields])) OR bacterial infections) OR Escherichia coli) OR Klebsiella pneumonia) OR Acinetobacter baumannii) OR Stenotrophomonas maltophilia) OR Burkholderia cepacia) OR Ralstonia pickettii) OR cross infection) OR nosocomial infection) OR (("nosocomial"[All Fields] AND "infection"[All Fields]) OR ("nosocomial infection"[All Fields]) OR "nosocomial infections"[All] OR ("nosocomial"[All Fields] AND "infections"[All Fields])) OR (("nosocomial"[All Fields] AND "infection"[All Fields]) OR ("nosocomial infection"[All Fields]) OR "nosocomial infections"[All] OR ("nosocomial"[All Fields] AND "infections"[All Fields]))) OR (("nosocomial"[All Fields] AND "infection"[All Fields]) OR "nosocomial infection"[All Fields] OR "nosocomial infections"[All Fields] OR ("nosocomial"[All Fields] AND "infections"[All Fields]))) OR "methicillin resistant staphylococcus aureus") OR "vancomycin resistant enterococci"))
Limits	English, 1/1/2004- present (6/5/2014**)**

Appendix D Cochrane Data Collection Form

Notes on using data extraction form:
Be consistent in the order and style you use to describe the information for each report.
Record any missing information as unclear or not described, to make it clear that the information was not found in the study report(s), not that you forgot to extract it.
Include any instructions and decision rules on the data collection form, or in an accompanying document.
It is important to practice using the form and give training to any other authors using the form.

Rationale or inclusion or exclusion	
Notes:	

Characteristics of included studies
Methods

	Descriptions as stated in report/paper	**Location in text or source** *(pg & ¶/fig/table/other)*
Aim of study *(e.g. efficacy, equivalence, pragmatic)*		
Design *(e.g. parallel, crossover, non-RCT)*		
Unit of allocation *(by individuals, cluster/ groups or body parts)*		
Start date		
End date		
Duration of participation *(from recruitment to last follow-up)*		
Ethical approval needed/ obtained for study	☐ Yes ☐ No ☐ Unclear	
Notes:		

Participants

	Description *Include comparative information for each intervention or comparison group if available*	Location in text or source *(pg & ¶/fig/table/other)*
Population description *(from which study participants are drawn)*		
Setting *(including location and social context)*		
Inclusion criteria		
Exclusion criteria		

Informed consent obtained	☐ Yes ☐ No ☐ Unclear		
Total no. randomized *(or total pop. at start of study for NRCTs)*			
Clusters *(if applicable, no., type, no. people per cluster)*			
Baseline imbalances			
Withdrawals and exclusions *(if not provided below by outcome)*			
Age			
Sex			
Race/Ethnicity			
Severity of illness			
Co-morbidities			
Other relevant sociodemographics			
Subgroups measure			
Subgroups reported			
Notes:			

Intervention groups
Copy and paste table for each intervention and comparison group
Intervention Group 1

	Description as stated in report/paper	Location in text or source *(pg & ¶/fig/table/other)*
Group name		
No. Randomized to group *(specify whether no. People or clusters)*		
Theoretical basis *(include key references)*		
Description *(include sufficient detail for replication, e.g. content, dose, components)*		
Duration of treatment period		
Timing *(e.g. frequency, duration of each episode)*		
Delivery *(e.g. mechanism, medium, intensity, fidelity)*		
Providers *(e.g. no., profession, training, ethnicity etc. if relevant)*		
Co-interventions		

Economic information *(i.e. intervention cost, changes in other costs as result of intervention)*		
Resource requirements *(e.g. staff numbers, cold chain, equipment)*		
Integrity of delivery		
Compliance		
Notes:		

Outcomes
Copy and paste table for each outcome.
Outcome 1

	Description as stated in report/paper		Location in text or source *(pg & ¶/fig/table/other)*
Primary Outcome			
Time points measured *(specify whether from start or end of intervention)*			
Time points reported			
Outcome definition *(with diagnostic criteria if relevant)*			
Person measuring/ reporting			
Unit of measurement *(if relevant)*			
Scales: upper and lower limits *(indicate whether high or low score is good)*			
Is outcome/tool validated?	☐ Yes ☐ No ☐ Unclear		
Imputation of missing data *(e.g. assumptions made for ITT analysis)*			
Assumed risk estimate *(e.g. baseline or population risk noted in Background)*			
Power *(e.g. power & sample size calculation, level of power achieved)*			
Secondary Outcomes			
Notes:			

Data and analysis

	Description as stated in report/paper	Location in text or source *(pg & ¶/fig/table/other)*

Comparison		
Subgroup		
Time point *(specify from start or end of intervention)*		
Results of Primary Outcome *(e.g. odds ratio, risk difference, CI or P value)* *(For Continuous:* Post-intervention or change from baseline?)		
Results of Secondary Outcome *(e.g. odds ratio, risk difference, CI or P value)*		
Statistical methods used and appropriateness of these *(e.g. adjustment for correlation)*		
Notes:		

No. Participant	Intervention	Control	

For Interrupted Time Series study (ITS)

For Interrupted Time Series study (ITS) Length of time points measured *(e.g. days, months)*		
Total period measured		

Other

Study funding sources *(including role of funders)*		
Possible conflicts of interest *(for study authors)*		
Key conclusions of study authors		
Limitations stated by study authors		
Notes:		

Appendix E Quality assessment tool
(*Published by Aboelela et al. (2006)*[2])

	Completely adequate	Partially adequate	Inadequate, not stated, or impossible to tell	Not applicable
Representativeness	All key characteristics of study population described	Some key characteristics described	Minimal to no description of key characteristics and inclusion/exclusion criteria	No control group
	Detailed inclusion/ exclusion criteria described	Some description of inclusion/ exclusion criteria		No inclusion/ exclusion criteria
Bias and confounding	Study population corresponded to larger population in all key factors	Sample population differed in some minor factors to larger population,	Sample population differed in several key factors to larger population	No control group Impossible to mask individuals
	Masking of all individuals	Masking of some individuals	No masking	
	Equivalent outcome assessment	Minor differences in outcome assessment	Major differences in outcome assessment	
	Appropriate level of involvement from authoring investigator	More of involvement from authoring investigator	Inappropriate involvement from authoring investigator	
	Study accounted for confounding interventions with respect to effectiveness of BP or SC	Study only partially accounted for confounding interventions with respect to effectiveness of BP or SC	Study did not account for confounding interventions with respect to effectiveness of BP or SC	
	Compliance rate greater that 80%	Compliance rate between 80% and 50%	Compliance rate below 50%	Study not monitored
Description of intervention	Protocol could be replicated given description of intervention and /or monitoring	Some minor or major details excluded from explanation of intervention and/or monitoring	No details given in description of intervention and monitoring	
Outcomes and follow-up	Outcome assessment procedure clearly defined	Outcome assessment procedure somewhat defined	Outcome assessment procedure not defined	No control groups–follow-up/ attrition not applicable
	Groups equivalent in attrition	Some difference in attrition	Major difference in attrition	
Statistical analysis	Statistical methods fully described and appropriate	Statistical methods partially described and appropriate	Statistical methods not described or absent or appropriate	N/A
	Tests addressed differences between groups and variability	Tests addressed some differences between groups and variability	Did not address differences between groups and variability	

Appendix F Consolidated Health Economic Evaluation Reporting Standards (CHEERS) Instrument

Section/item	Item no	Recommendation
Title and abstract		
Title	1	Identify the study as an economic evaluation or use more specific terms such as "cost-effectiveness analysis", and describe the interventions compared
Abstract	2	Provide a structured summary of objectives, perspective, setting, methods (including study design and inputs), results (including base case and uncertainty analyses), and conclusions
Introduction		
Background and objectives	3	Provide an explicit statement of the broader context for the study Present the study question and its relevance for health policy or practice decisions
Methods		
Target population and subgroups	4	Describe characteristics of the base case population and subgroups analysed, including why they were chosen
Setting and location	5	State relevant aspects of the system(s) in which the decision(s) need(s) to be made
Study perspective	6	Describe the perspective of the study and relate this to the costs being evaluated
Comparators	7	Describe the interventions or strategies being compared and state why they were chosen
Time horizon	8	State the time horizon(s) over which costs and consequences are being evaluated and say why appropriate
Discount rate	9	Report the choice of discount rate(s) used for costs and outcomes and say why appropriate
Choice of health outcomes	10	Describe what outcomes were used as the measure(s) of benefit in the evaluation and their relevance for the type of analysis performed
Measurement and valuation of preference based outcomes	12	If applicable, describe the population and methods used to elicit preferences for outcomes
Estimating resources and costs	13a	*Single study-based economic evaluation:* Describe approaches used to estimate resource use associated with the alternative interventions. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs
	13b	*Model-based economic evaluation:* Describe approaches and data sources used to estimate resource use associated with model health states. Describe primary or secondary research methods for valuing each resource item in terms of its unit cost. Describe any adjustments made to approximate to opportunity costs
Currency, price date, and conversion	14	Report the dates of the estimated resource quantities and unit costs. Describe methods for adjusting estimated unit costs to the year of reported costs if necessary. Describe methods for converting costs into a common currency base and the exchange rate
Choice of model	15	Describe and give reasons for the specific type of decision-analytical model used. Providing a figure to show model structure is strongly recommended
Assumptions	16	Describe all structural or other assumptions underpinning the decision-analytical model
Analytical methods	17	Describe all analytical methods supporting the evaluation. This could include methods for dealing with skewed, missing, or censored data; extrapolation methods; methods for pooling data; approaches to validate or make adjustments (such as half cycle corrections) to a model; and methods for handling population heterogeneity and uncertainty

Results		
Study parameters	18	Report the values, ranges, references, and, if used, probability distributions for all parameters. Report reasons or sources for distributions used to represent uncertainty where appropriate. Providing a table to show the input values is strongly recommended
Incremental costs and outcomes	19	For each intervention, report mean values for the main categories of estimated costs and outcomes of interest, as well as mean differences between the comparator groups. If applicable, report incremental cost-effectiveness ratios
Characterising uncertainty	20a	*Single study-based economic evaluation:* Describe the effects of sampling uncertainty for the estimated incremental cost and incremental effectiveness parameters, together with the impact of methodological assumptions (such as discount rate, study perspective)
	20b	*Model-based economic evaluation:* Describe the effects on the results of uncertainty for all input parameters, and uncertainty related to the structure of the model and assumptions
Characterising heterogeneity	21	If applicable, report differences in costs, outcomes, or cost-effectiveness that can be explained by variations between subgroups of patients with different baseline characteristics or other observed variability in effects that are not reducible by more information
Discussion		
Study findings, limitations, generalisability, and current knowledge	22	Summarise key study findings and describe how they support the conclusions reached. Discuss limitations and the generalisability of the findings and how the findings fit with current knowledge
Other		
Source of funding	23	Describe how the study was funded and the role of the funder in the identification, design, conduct, and reporting of the analysis. Describe other non-monetary sources of support
Conflicts of interest	24	Describe any potential for conflict of interest of study contributors in accordance with journal policy. In the absence of a journal policy, we recommend authors comply with International Committee of Medical Journal Editors recommendations

Appendix G QHES Quality Assessment Instrument

QHES Topic	QHES Prompt	Weight
Objective	Was the study objective presented in a clear, specific, and measureable manner?	7
Perspective	Were the perspective of the analysis (societal, third-party payer, etc.) and reasons for its selection stated?	4
Estimate Quality	Were variables estimates used in the analysis from the best available source (i.e., randomized control trial - best, expert opinion - worst)?	8
Subgroups*	If estimates came from a subgroup analysis, were the groups pre-specified at the beginning of the study?	1
Statistics/ Sensitivity	Was uncertainty handled by (1) statistical analysis to address random events, (2) sensitivity analysis to cover a range of assumptions?	9
Alternatives	Was incremental analysis performed between alternatives for resources and costs?	6
Abstraction Method	Was the methodology of data abstraction (including value health states and other benefits) stated?	5
Horizon/ Discount	Did the analytic horizon allow time for all relevant and important outcomes? Were benefits and costs that went beyond discounted (3 to 5%) and justification given for the discount rate?	7
Cost Measures	Was the measurement of costs appropriate and the methodology for the estimation of quantities and unit costs clearly described?	8
Primary Outcomes	Were the primary outcomes measure(s) for the economic evaluation clearly stated and did they include major short-term, long-term and negative outcomes?	6
Health Measures	Were the health outcomes measures/scales valid and reliable? If previously tested valid and reliable measures were not available, was justification given for the measures/scales used?	7
Model Components	Were the economic model (including structure), study methods and analysis, and the components of the numerator and denominator displayed in a clear transparent manner?	8
Model Justification	Were the choice of economic model, main assumptions and limitations of the study stated and justified?	7
Bias	Did the author(s) explicitly discuss direction and magnitude of potential biases?	6
Conclusions	Were the conclusions/recommendations of the study justified and based on the study results?	8
Funding	Was there a statement disclosing the source of funding for the study?	3

*Authors interpreted this item in cases where subgroups were not appropriate that studies of high quality have assessed and stated the heterogeneity of the study sample either prospectively or retrospectively.

Appendix H Topics of qualitative directed content analysis

Topic	Information Recorded
Organisms	What are all the organisms that can trigger isolation-based practices in this facility? (As listed by the interviewee, including the location, if applicable, e.g., methicillin-resistant *Staphylococcus aureus* of the nares)
Residents	Which residents are isolated? (i.e., resident characteristics leading to isolation)
Decision	How does the staff decide to initiate isolation and who makes the decision to initiate isolation? (e.g., laboratory cultures, etc., not including resident characteristics recorded for the above question)
Private space	What are the semi-private or private spaces where isolated individuals reside? (List possibilities, e.g., *Clostridium difficile* residents always have a private commode, or ocular herpes cases are confined to a private room)
Shared Space	What are the shared spaces where isolated residents are allowed? (If interviewees make references to an isolated resident being allowed outside his/her room, assume that they are allowed in all shared spaces unless otherwise stated, e.g., bathrooms, hallways, dining room, recreation room, therapy room)
Personal Protective Equipment (PPE)	What PPE is required for the staff and/or residents as part of isolation-based infection prevention and control practices in the facility, including gowns, gloves, masks, other (specify)?
Processes	What are the processes for contact with “isolated” residents besides hand hygiene, if any?
Removal	When are residents taken off isolation precautions?
Communication	How are changes in precautions communicated to the staff?
Cleaning	What are the policies regarding cleaning rooms of isolated residents?
Linens	What are the policies regarding cleaning linens from isolated residents?
Facilitators	What are the facilitators to isolation-based infection prevention and control practices?
Barriers	What are the barriers to isolation-based infection prevention and control practices?
Perceptions	Description of any ethical considerations, concerns or other perceptions of the staff regarding isolation.
Non-compliance	How does the facility handle non-compliance with isolation-based techniques? (Including staff, residents and visitor non-compliance)
Disagreement	To what extent is there disagreement between staff about isolation policies?

Appendix I Consolidated Criteria for Reporting Qualitative Research (COREQ) checklist for interviews and focus groups items

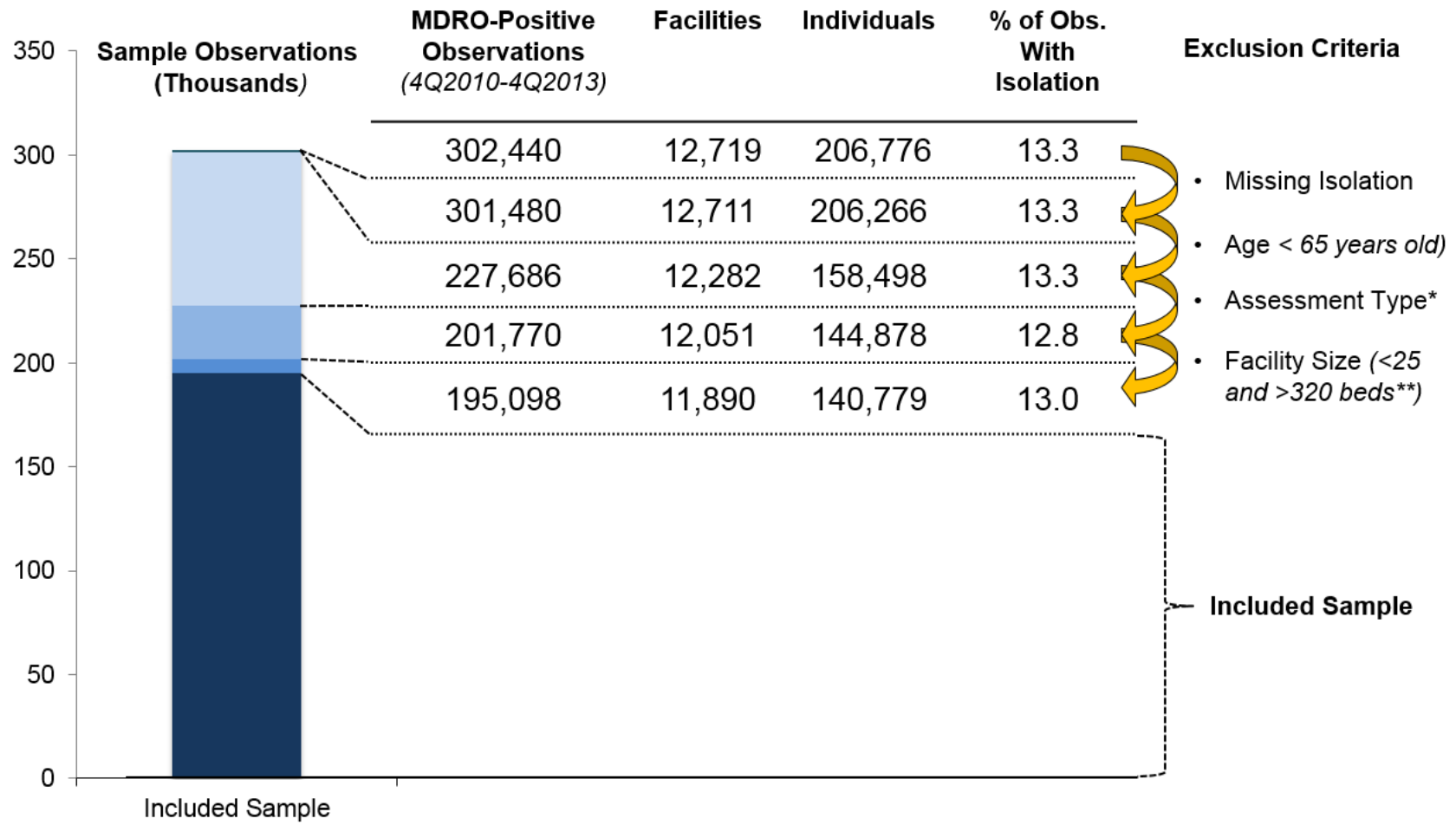
Domain/ Item	Information	Location
Domain 1: Research team and reflexivity		
1. Interviewer/facilitator	*"Members of our study team (3 male, 5 female) conducted in-depth, semi-structured interviews from May through September 2013. … All interviewers were trained on in-depth qualitative interviewing techniques and encouraged to manually record field notes regarding observations not captured in the interview."* [Also see acknowledgement section.]	p. 5, 14
2. Credentials	See Table 1 in Stone et al.	Stone et al. (2015), p. 2
3. Occupation	See Table 1 in Stone et al.	Stone et al. (2015), p. 2
4. Gender	*"Members of our study team (3 male, 5 female) conducted in-depth, semi-structured interviews"*	p. 5
5. Experience and training	*"Team members attended training sessions conducted by an expert qualitative consultant."*	Stone et al. (2015), p. 2
Relationship with participants		
6. Relationship established	*"Our interdisciplinary team is multidisciplinary and no one had prior relationships with any of the study sites."*	Stone et al. (2015), p. 2
7. Participant knowledge of the interviewer	*"All interviewees were informed of study goals and provided written informed consent."*	p. 5
8. Interviewer characteristics	*"All interviewers were trained on in-depth qualitative interviewing techniques and encouraged to manually record field notes regarding observations not captured in the interview.*	p. 5
Domain 2: Study design		
Theoretical framework		
9. Methodological orientation and theory	*"Each interviewee was interviewed once, one-on-one, with an interview guide informed by Donabedian's healthcare quality theoretical framework[63] … A directed content analysis of all transcripts was performed (see Appendix A for directed content)."*	p. 5
Participant selection		
10. Sampling	*"Each NH was purposively selected with the goal of obtaining variation in geographic region, size, ownership status and 3-year infection control deficiency citation performance. The deficiency citation score is derived from*	p. 4

		infection control-related evaluation criteria found in annual, unscheduled inspections by the state that are required for Medicare and Medicaid certification and reimbursement (deficiency citations indicate poor performance). […] *We aimed to recruit interviewees who were familiar with the facility based on tenure and who would provide range of perspectives based on role (e.g., infection prevention directors, directors of nursing, assistant directors of nursing, medical directors, environmental service workers and staff nurses).”*	
	11. Method	*“NHs were recruited through informational mailings, follow-up phone calls and emails. At each facility, a site contact was identified who then recruited individual interviewees based on our guidelines for inclusion.[156]”*	p. 4
	12. Sample size	*"In total, 10 NHs were visited and 73 interviews were conducted, with 6-8 interviewees per facility."*	p. 6
	13. Non-participation	“*Recruitment concluded when data saturation across the entire NH sample was achieved for all infection control-related topics covered by the interview guides.[75]”*	p. 5
Setting			
	14. Setting	*“Each interviewee was interviewed once, one-on-one””*	p. 5
	15. Presence of non-participants	See above	p. 5
	16. Description of sample	*“From May to September 2013, 10 NHs were visited (see Table 2). Forty percent were non-profit, and bed size ranged from 40 to 204. Geographic location was diverse with 3 in the Northeast region, 3 in the West or Midwest, and 4 in the South. Facilities were evenly dispersed into the low and high three-year infection related citation score categories. A total of 73 interviews were conducted. Often the participants served in multiple capacities; Table 3 shows these multiple roles by listing the participants’ role as identified by the site coordinator and the corresponding interview guide that was used as well as the other roles identified in the interview process. Only 9 IPs were interviewed because of a leave of absence at one site. Table 4 lists the 5 themes that emerged, a short explanation, and provides exemplar quotes.”*	Stone et al. (2015), p. 2
Data collection			
	17. Interview guide	*“Semi-structured interview guides (available upon request) and in-depth interviewing techniques were used.21 The guides were developed, reviewed and piloted by NH experts including IPs working within this setting and reflected our understanding of the significant issues of IPC in NHs from the literature and identified in guidelines.8,18,19 Using a semi structured interview format facilitated the exploration of new ideas.”*	Stone et al. (2015), p. 2
	18. Repeat interviews	*“Each interviewee was interviewed once, one-on-one”*	p. 5
	19. Audio/visual	*“Interviews were digitally recorded and transcribed verbatim.”*	p. 5

	20. Field notes	*"All interviewers were trained on in-depth qualitative interviewing techniques and encouraged to manually record field notes regarding observations not captured in the interview."*	p. 4
	21. Duration	*"On average, interviews lasted approximately 45 minutes."*	p. 6
	22. Data saturation	*"Recruitment concluded when data saturation across the entire NH sample was achieved for all infection control-related topics covered by the interview guides.[75]"*	p. 5
	23. Transcripts returned	*"While we were not able to have each interviewee review transcripts, in an effort to conduct member-checking, each NH was sent a summary of the findings from their facility and no corrections were offered."*	p. 13-4
Domain 3: Analysis and finding			
Data analysis			
	24. Number of data coders	*"Using Microsoft Excel[106] software to facilitate coding and analysis, CCC and MPM reviewed the extracted passages, generated a comprehensive set of primary and secondary codes and drafted definitions for each.*"	p. 5
	25. Description of the coding tree	Please see Appendix A for directed content. "*Throughout the narratives we found that decision-making to use isolation practices was complex and this could be attributed to four themes that emerged: 1) perceived risk of transmission; 2) conflict with quality of life goals; 3) resource availability; and 4) lack of understanding regarding infection prevention and control. Each of these themes are outlined in Figure 1"*	p. 6
	26. Derivation of themes	*"A directed content analysis of all transcripts was performed (see Appendix A for directed content). This analytic technique is used to focus the research question, helps to determine the initial coding scheme and is useful when existing theory or prior research insufficiently describes a particular phenomenon.[81] A keyword search of all transcripts was conducted in NVivo 10 (QSR International[129] software using "isolation" and related terms (e.g., isolate, contact precaution, contact isolation, isolation precaution, cohort, quarantine, outbreak, cart, special precautions, single room, private room, signs, mask, gown, roommate) to highlight passages of text pertaining to the phenomena of interest. A keyword search is beneficial in content analysis when a large volume of text is available as it allows researchers to target passages with pertinent content to focus in-depth analysis.[144] Using Microsoft Excel[106] software to facilitate coding and analysis, CCC and MPM reviewed the extracted passages, generated a comprehensive set of primary and secondary codes and drafted definitions for each. Emerging themes were discussed weekly with all authors to ensure a shared understanding."*	p. 5

	27. Software	*"A keyword search of all transcripts was conducted in NVivo 10 (QSR International[129] software … Using Microsoft Excel[106] software to facilitate coding and analysis"*	p. 5
	28. Participant checking	*"While we were not able to have each interviewee review transcripts, in an effort to conduct member-checking, each NH was sent a summary of the findings from their facility and no corrections were offered."*	p. 13-4
Reporting			
	29. Quotations presented	See results section	p. 5-11
	30. Data and findings	See results section, See Figure 1 for themes overview	p. 5-11
	31. Clarity of major themes	See results section	p. 5-11
	32. Clarity of minor themes	Not applicable	

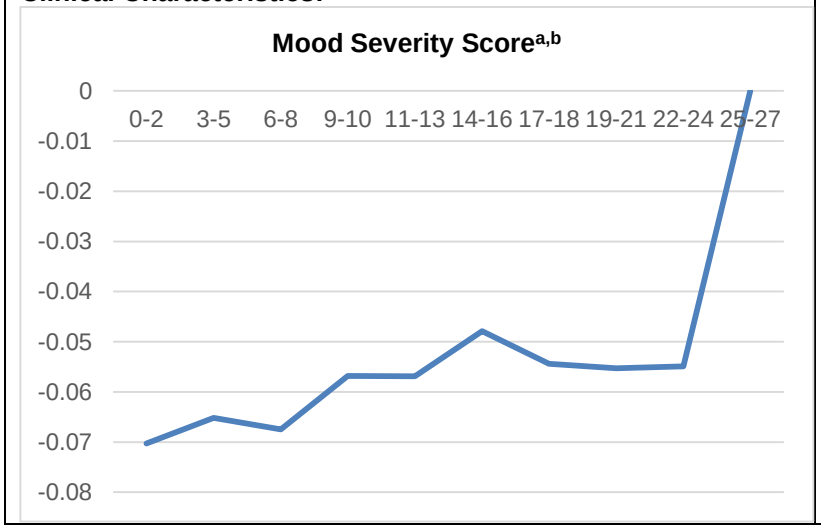
Appendix J Sampling criteria and refinement



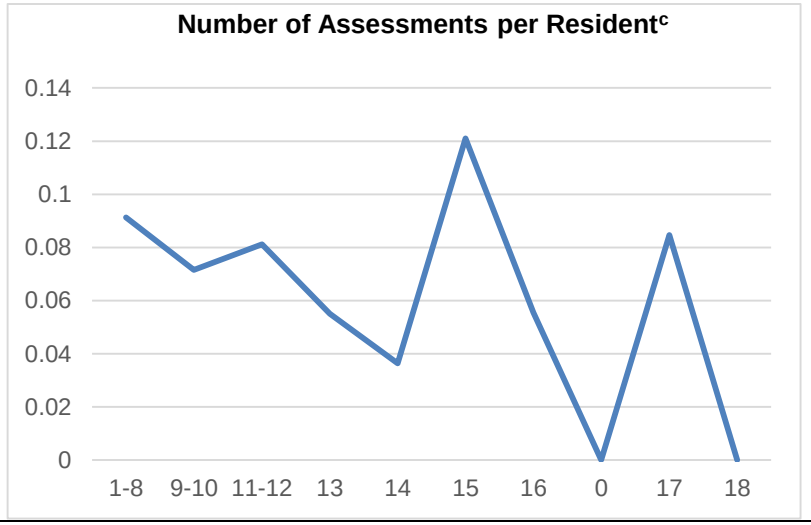
*Observations that are a significant change in status assessment or missing assessment type were excluded.
** 98th percentile is included

Appendix K Functional forms of associations between continuous variables and probability of isolation precaution use.
(Preliminary main effects multivariable logistic regressions with facility-level clustered robust standard errors).

Clinical Characteristics:

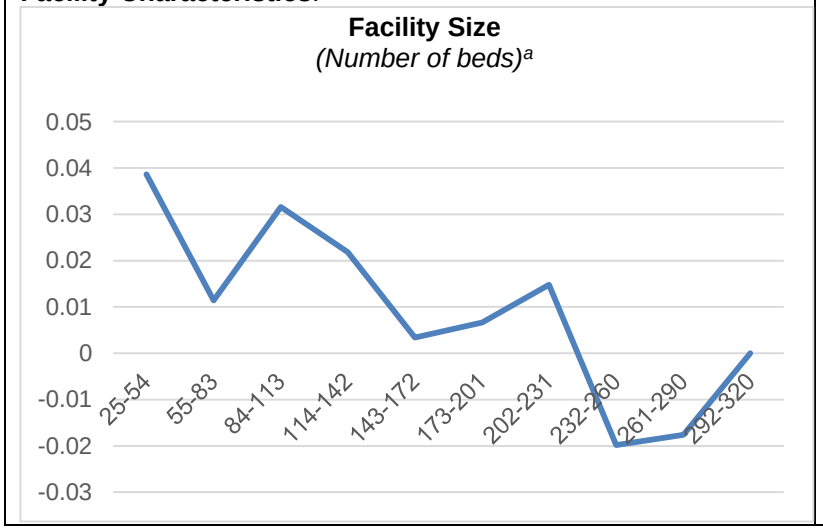


Clinical Characteristics:



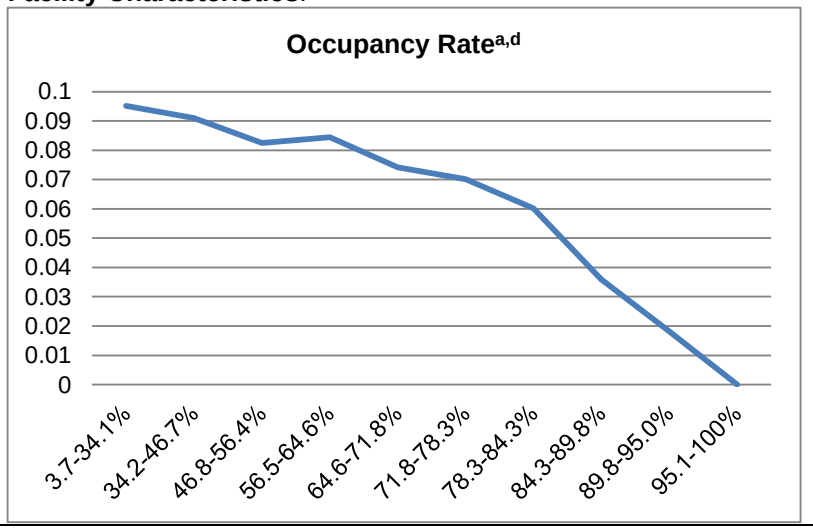
Facility Characteristics:

Facility Size
(Number of beds)[a]



Facility Characteristics:

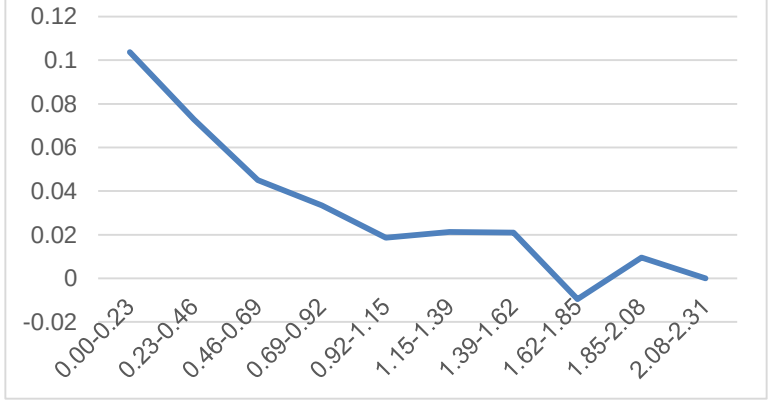
Occupancy Rate[a,d]



Facility Characteristics:

Staffing: Registered Nurses[a,d]

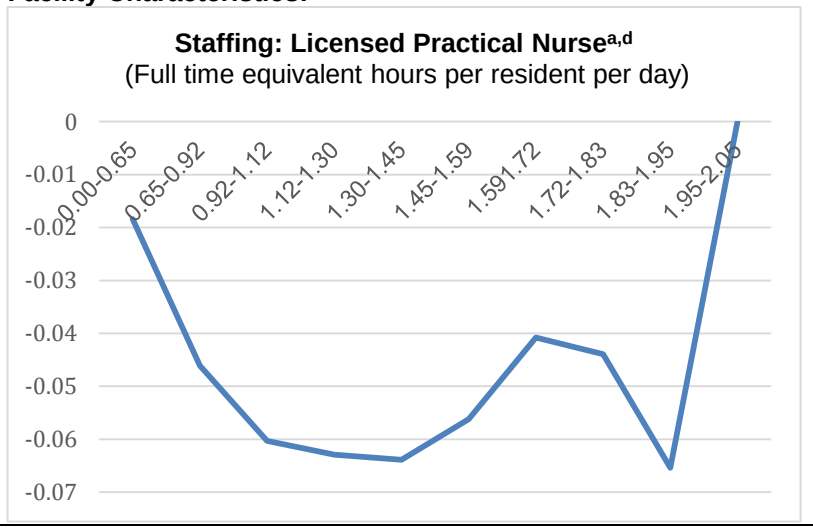
(*Full time equivalent hours per resident per day)*



Facility Characteristics:

Staffing: Licensed Practical Nurse[a,d]

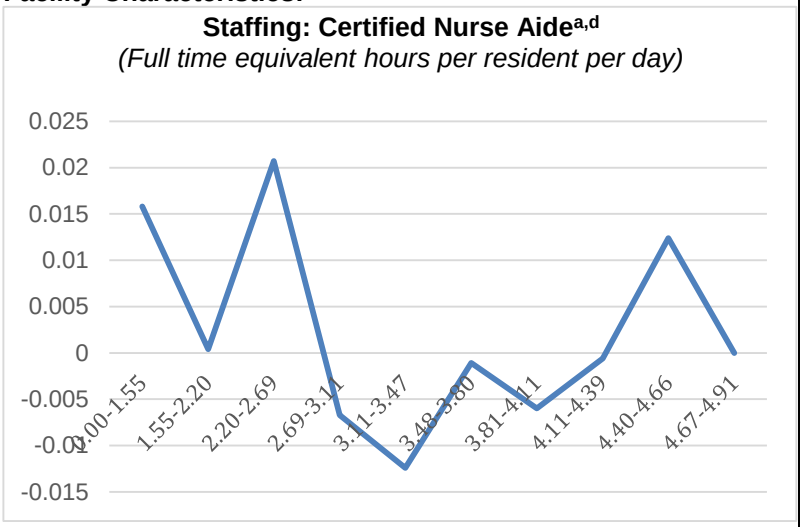
(Full time equivalent hours per resident per day)



Facility Characteristics:

Staffing: Certified Nurse Aide[a,d]

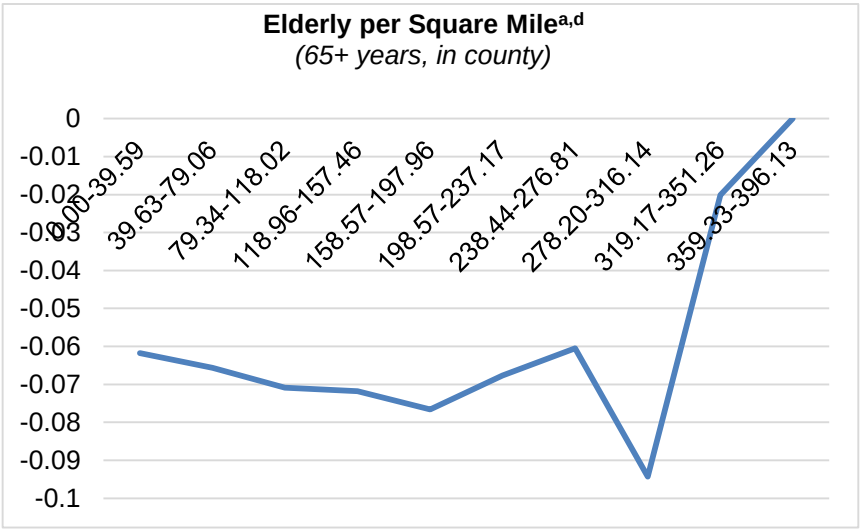
(Full time equivalent hours per resident per day)



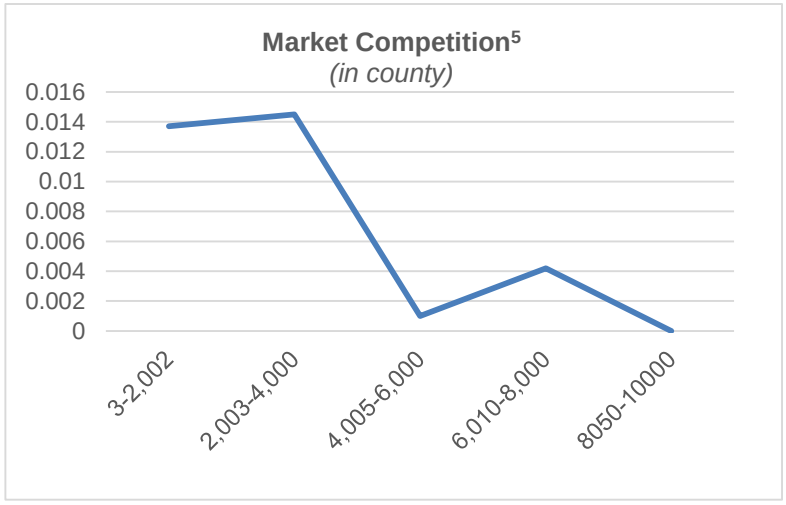
Location Characteristics:

Elderly per Square Mile[a,d]

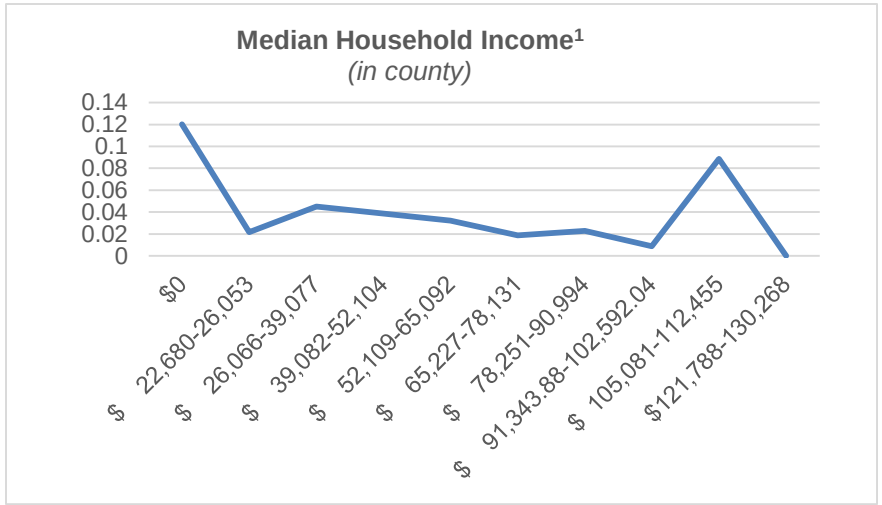
(65+ years, in county)

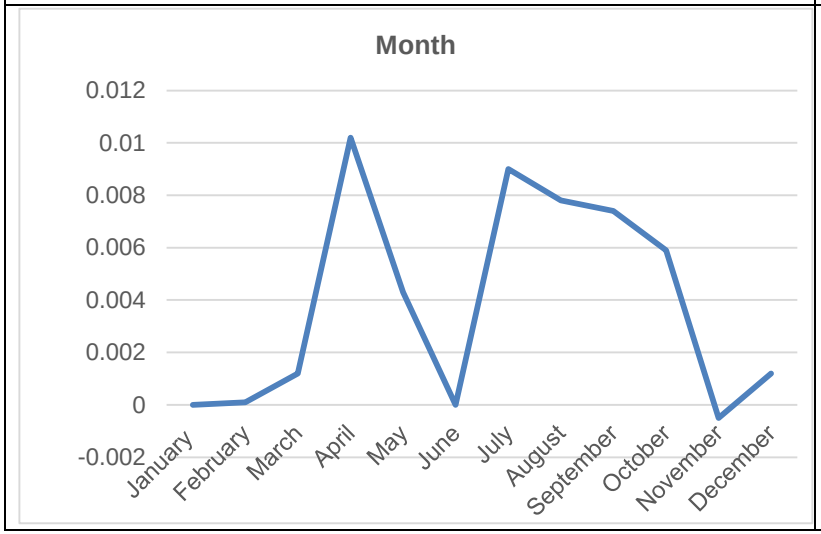


Location Characteristics:

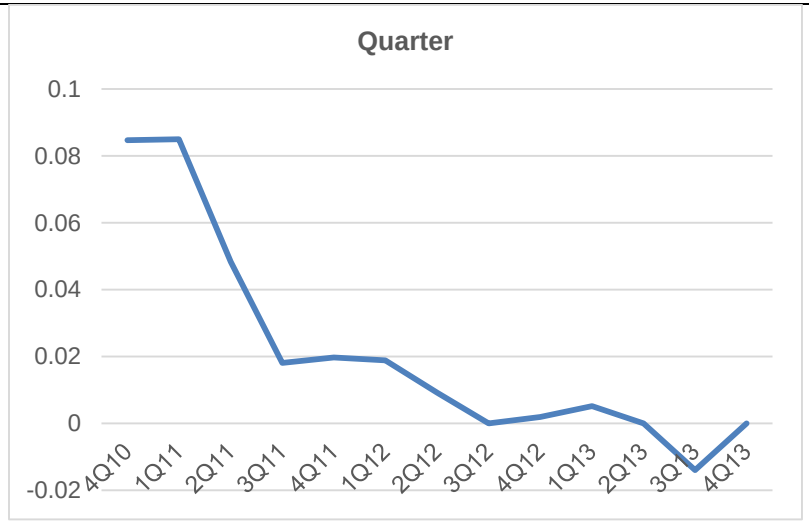


Location Characteristics:





Other:



Note: [a]Standardized and divided into 10 categories by value, with highest as the reference. [b]Higher mood score represents worse condition [c]Standardized and divided into 5 categories by value, with highest as the reference; [d]Highest 1% of values excluded as outliers. [e]Capped at 1 (100% occupancy). [f]Herfindahl index, highest indicates complete market share of beds in the county and lower number indicates a more competitive market.

Appendix L Results of full multivariable linear probability model results
(1) with facility-level clustered robust standard errors and (2) facility-level fixed effects.
Dependent variable: Isolation precautions
The final regression sample included 11,830 unique nursing homes, 188,059 observations.

	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
Predictor	***B***	**SE**	***P***	***B***	**SE**	***P***
Resident Demographics						
Female gender	-0.0014	0.0019	.47	-0.0043	0.0014	< .001
Race (ref: *White, not Hispanic)*						
American Indian or Alaskan Native	-0.0418	0.0166	.01	-0.0112	0.0131	.39
Asian	0.0332	0.0144	.02	-0.0043	0.0077	.58
Black, not Hispanic	0.0194	0.0052	< .001	0.0024	0.0029	.41
Native Hawaiian/ Pacific Islander	-0.0201	0.0158	.2	-0.0039	0.0143	.78
Unknown, not Hispanic	-0.0049	0.0073	.5	-0.0058	0.005	.25
Black, Hispanic	-0.0306	0.1159	.79	0.0333	0.1021	.74
White, Hispanic	0.0124	0.0627	.84	-0.0085	0.0421	.84
Hispanic, unknown race	0.0259	0.008	< .001	-0.0016	0.0043	.71
Unknown Race/Ethnicity	0.1921	0.0789	.01	0.0399	0.025	.11
Clinical Characteristics						
Activities of daily living: Bed mobility[a]						
Supervision needed	0.0011	0.0074	.88	-0.0005	0.006	.93
Support needed/activity did not occur	-0.0227	0.0066	< .001	-0.0129	0.0052	.01
Activities of daily living: Dressing[a]						
Supervision needed	0.006	0.0091	.51	0.0016	0.0079	.84
Support needed/activity did not occur	0.0041	0.0096	.67	0.0058	0.0077	.45
Activities of daily living: Eating[a]						
Supervision needed	0.0038	0.0038	.31	0.002	0.0021	.34
Support needed/activity did not occur	0.0342	0.0048	< .001	0.0215	0.0025	< .001
Activities of daily living: Hygiene[a]						
Supervision needed	-0.0057	0.0072	.43	-0.0099	0.0057	.08
Support needed/activity did not occur	0.0042	0.0076	.58	-0.0072	0.0055	.19
Activities of daily living: Locomotion[a]						
Supervision needed	-0.0012	0.0045	.78	0.0029	0.004	.47
Support needed/activity did not occur	0.0245	0.0039	< .001	0.0252	0.0033	< .001
Activities of daily living: Tolieting[a]						
Supervision needed	-0.0065	0.0084	.44	0.0111	0.0079	.16
Support needed/activity did not occur	-0.0074	0.0085	.38	0.0086	0.0077	.27
Activities of daily living: Transfer[a]						
Supervision needed	0.0041	0.008	.61	0.001	0.0074	.89

Predictor	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
Support needed/activity did not occur	0.0107	0.0081	.19	-0.0036	0.0072	.62
Admissions assessment	0.0449	0.0032	< .001	0.0486	0.002	< .001
Behavioral problem: Physical[b]						
Occurred 1-3 of last 7 days	-0.0104	0.0053	.05	-0.0018	0.005	.72
Occurred ≥4 of last 7 days	0.009	0.0131	.49	0.0102	0.0091	.26
Behavioral problem: Verbal[b]						
Occurred 1-3 of last 7 days	0.0026	0.0046	.56	-0.0028	0.004	.5
Occurred ≥4 of last 7 days	0.0272	0.0098	.01	0.0035	0.0071	.62
Behavioral problem: Other[b]						
Occurred 1-3 of last 7 days	-0.005	0.0045	.27	0.0015	0.0042	.71
Occurred ≥4 of last 7 days	-0.0022	0.0065	.73	-0.006	0.0053	.26
Dementia diagnosis, Alzheimer's	-0.0062	0.0046	.18	-0.0016	0.0038	.68
Dementia diagnosis, not Alzheimer's	0.0045	0.0056	.42	0.0082	0.0045	.07
History of MDRO-positive MDS assessment						
(Before current assessment)	-0.0273	0.0023	< .001	-0.0192	0.0019	< .001
Indwelling catheter	0.0172	0.0025	< .001	0.0104	0.0017	< .001
Influenza vaccination in current season	-0.0062	0.0025	.01	-0.0041	0.0019	.03
Long-stay status						
(> 100 days in facility)	-0.0151	0.0032	< .001	-0.0046	0.0024	.06
Mood Severity Score *(ref: 25-27)*[c]						
0-2	-0.0644	0.0612	.29	-0.0647	0.0437	.14
3-5	-0.0589	0.0612	.34	-0.0578	0.0437	.19
6-8	-0.0617	0.0612	.31	-0.0586	0.0438	.18
9-10	-0.0521	0.0613	.4	-0.0541	0.0438	.22
11-13	-0.0511	0.0612	.4	-0.0564	0.0439	.2
14-16	-0.0426	0.0617	.49	-0.0493	0.0441	.26
17-18	-0.0503	0.0625	.42	-0.0451	0.0447	.31
19-21	-0.0455	0.0624	.47	-0.0486	0.0454	.28
22-24	-0.0519	0.0648	.42	-0.0473	0.0479	.32
Mood is Missing	0.0111	0.0038	< .001	0.0088	0.0025	< .001
Number of assessments per resident *(ref: 15-18 assessments)*						
1-4	0.022	0.0268	.41	-0.0106	0.0191	.58
5-7	0.0067	0.0269	.8	-0.0167	0.0191	.38
8-11	-0.0025	0.0271	.93	-0.0121	0.0193	.53
12-14	-0.0099	0.0266	.71	-0.0133	0.02	.5
Ability to make self understood *(Ref: Is understood)*						
Usually	0.0051	0.0036	.15	-0.0002	0.0022	.93
Sometimes/rarely/never	0.0065	0.0059	.27	0.0044	0.0037	.23
Wandering *(ref: no wandering)*						
1-3 days of last week	-0.0284	0.0066	< .001	-0.0256	0.0067	< .001
4-6 days of last week	-0.0402	0.0116	< .001	-0.0383	0.0121	< .001
Daily wandering in last week	-0.0257	0.011	.02	-0.0212	0.0093	.02

Predictor	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
Facility Characteristics						
Chain membership	-0.0315	0.0051	< .001	0.0018	0.0042	.67
Citation on last inspection: *Infection Control*	0.0166	0.0037	< .001	0.0043	0.0019	.02
Citation on last inspection: *Care quality*	-0.003	0.0038	.44	-0.0043	0.002	.03
Facility size *(*number of beds*)*	-0.0528	0.0135	< .001	-0.3465	0.0573	< .001
Occupancy rate[d] *(ref: 95.1-100%)*						
Continuous	0.3821	0.1186	< .001	-0.0069	0.0865	.94
Squared	-0.3909	0.078	< .001	-0.0547	0.055	.32
Ownership status *(ref: For-profit)*						
Government	0.0099	0.012	.41	-0.0197	0.0143	.17
Not for-profit	-0.0127	0.0055	.02	0.0239	0.0086	.01
Staffing: Registered nurses[c,e,f] *(ref: 0.46-0.69)*						
0.00-0.23	0.0644	0.02	< .001	0.0083	0.0111	.45
0.23-0.46	0.0283	0.0062	< .001	-0.0065	0.0034	.06
0.69-0.92	-0.0127	0.0049	.01	-0.0004	0.0027	.87
0.92-1.15	-0.026	0.0067	< .001	0.0008	0.004	.84
1.15-1.39	-0.025	0.01	.01	-0.0037	0.0056	.51
1.39-1.62	-0.0259	0.0148	.08	0.0037	0.0077	.63
1.62-1.85	-0.0487	0.022	.03	-0.0246	0.0104	.02
1.85-2.08	0.0069	0.0381	.86	-0.0348	0.0138	.01
2.08-2.31	-0.0392	0.0432	.36	0.0132	0.0174	.45
Top 1% of RN staffing levels	0.0644	0.02	< .001	0.0083	0.0111	.45
Staffing: Licensed practical nurse[e,f]						
Continuous	-0.1743	0.0603	< .001	-0.0711	0.0307	.02
Squared	0.2064	0.071	< .001	0.0528	0.033	.11
Top 1% of LPN staffing levels	0.0032	0.0311	.92	-0.0027	0.0135	.84
Staffing: Certified nurse aide[e,f]						
Continuous	-0.0655	0.072	.36	0.043	0.0354	.22
Squared	0.0841	0.0738	.25	-0.0815	0.0372	.03
Top 1% of Aide staffing levels	0.0594	0.0368	.11	0.0218	0.0166	.19
Location Characteristics						
Elderly per square mile[c,f] *(65+ years, in county, ref: 359.33-396.13)*						
0.00-39.59	-0.1709	0.0424	< .001	-0.0201	0.0769	.79
39.63-79.06	-0.1687	0.0396	< .001	0.0239	0.0759	.75
79.34-118.02	-0.1641	0.0368	< .001	-0.021	0.0751	.78
118.96-157.46	-0.1478	0.0327	< .001	-0.0009	0.0744	.99
158.57-197.96	-0.1448	0.03	< .001	0.0424	0.072	.56
198.57-237.17	-0.1193	0.026	< .001	0.0262	0.0715	.71
238.44-276.81	-0.0993	0.0252	< .001	0.0242	0.0712	.73
278.20-316.14	-0.1137	0.0242	< .001	0.0478	0.0706	.5
319.17-351.26	-0.0426	0.0306	.16	0.0167	0.0691	.81

Predictor	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
Market Competition *(in county, ref: 8050-10000)*						
3 - 2,002	0.0348	0.0304	.25	-0.0257	0.0252	.31
2,003 - 4,000	0.0287	0.0255	.26	-0.0231	0.0224	.3
4,005 - 6,000	0.0085	0.0214	.69	-0.0214	0.0177	.22
6,010 - 8,000	0.0121	0.0197	.54	-0.0094	0.0154	.54
Median household income[c] *(in county, ref: $121,788-130,268)*						
$ 0	0.1228	0.098	.21	0	.	.
$ 22,680 – 26,053	-0.0017	0.0915	.98	0.0161	0.0828	.85
$ 26,066 – 39,077	0.0283	0.08	.72	0.0194	0.0299	.52
$ 39,082 – 52,104	0.0132	0.0778	.87	-0.0002	0.0282	.99
$ 52,109 – 65,092	0.0054	0.0769	.94	-0.0038	0.0276	.89
$ 65,227 - 78,131	0.0166	0.0767	.83	-0.001	0.0264	.97
$ 78,251 – 90,995	0.0193	0.0758	.8	0.0243	0.024	.31
$ 91,344 – 10,2592	0.0383	0.0792	.63	0	.	.
$ 105,081 - 112,455	0.0832	0.0805	.3	0	.	.
Other Predictors						
Quarter of assessment *(Time trend, ref: Q4 2013)*						
Q4 2010	0.0879	0.0067	< .001	0.1071	0.004	< .001
Q1 2011	0.0856	0.006	< .001	0.0972	0.0036	< .001
Q2 2011	0.0545	0.0055	< .001	0.0621	0.0036	< .001
Q3 2011	0.0274	0.0051	< .001	0.0347	0.0036	< .001
Q4 2011	0.0224	0.0051	< .001	0.0281	0.0036	< .001
Q1 2012	0.019	0.0047	< .001	0.0238	0.0035	< .001
Q2 2012	0.0132	0.0046	< .001	0.0161	0.0035	< .001
Q3 2012	0.0071	0.0044	.11	0.0115	0.0035	< .001
Q4 2012	0.0022	0.0044	.61	0.0051	0.0035	.14
Q1 2013	0.0026	0.0042	.53	0.0029	0.0035	.4
Q2 2013	0.0014	0.004	.72	0.0023	0.0035	.51
Q3 2013	-0.0084	0.0037	.02	-0.0043	0.0035	.21
Interaction terms						
Is understood and verbal behavior problem	-0.0085	0.0031	.01	-0.0047	0.0026	.06
Dementia and is understood	-0.001	0.0025	.69	0	0.0018	.99
Dementia and hygiene ADLs	0.0061	0.006	.31	0.0061	0.0058	.29
Dementia and eating ADLs	-0.0098	0.0026	< .001	-0.0074	0.002	< .001
Dementia and toileting ADLs	0.0122	0.0067	.07	0.0085	0.0063	.18
Dementia and dressing ADLs	-0.0191	0.0074	.01	-0.0202	0.0071	< .001
Market competition and elderly per square mile	-0.0404	0.0567	.48	0.3108	0.1498	.04
Market competition and median household income	0.0472	0.0954	.62	-0.0488	0.0864	.57
Median household income and Elderly per square mile	-0.265	0.102	.01	-0.4513	0.2082	.03
Constant	0.2882	0.1349	0.03	0.3973	0.109	< .001

Note: Adjusted R^2: Model 1) .05, Model 2) .03. Model 2 C-statistic: .59. [a]Activities of daily living reference categories are “independent”; [b]Behavioral problem-related items reference “behavior not exhibited”; [c]Standardized and divided into 10 categories by value, with highest as the reference; [d]Capped at 1 (100% occupancy); [e]Measured in full-time equivalent hours per resident per day; [f]Highest 1% of values excluded as outliers; [g]Standardized and divided into 5 categories by value, with highest as the reference.

Appendix M Joint contribution tests from full logistic regression model with facility fixed effects.
Dependent variable: Isolation Precautions.

Predictor	Joint Contribution	
	F-value	Probability > F
Resident Demographics		
Race	0.68	.731
Clinical Characteristics		
Activities of daily living:		
Bed mobility	4.62	.010**
Dressing	0.44	.644
Eating	50.71	< .001***
Hygiene	1.51	.221
Locomotion	46.84	< .001***
Toileting	1.0	.367
Transfer	0.36	.697
Behavioral problem:		
Physical	0.76	.466
Verbal	0.48	.616
Other	0.76	.468
Dementia diagnosis	3.73	.024*
Mood Severity Score	3.73	.001**
Number of assessments per resident	0.98	.416
Ability to make self understood	0.99	.373
Wandering	9.32	< .001***
Facility Characteristics		
Occupancy rate[a]	16.44	< .001***
Ownership Status	5.93	.003*
Staffing		
Registered Nurses[b]	2.46	.008**
Licensed Practical Nurses[b]	4.18	.015*
Certified Nurse Aides[b]	5.34	.005**
Location Characteristics		
Elderly per square mile[b] *(65+ years, in county)*	5.79	< .001***
Market competition[c] *(in county)*	0.44	0.7811
Median household income *(in county)*	1.89	0.079
Other Predictors		
Quarter of assessment *(time trend)*	150.73	< .001***
Interaction Terms		
Dementia and activities of daily living	7.36	< .001***
County-level variables	2.90	.033*

Note: Adjusted $R^{2:}$ .03, C-statistic: .59.[a]Capped at 1 (100% occupancy). [b]Highest 1% of values excluded as outliers. [c]Herfindahl Index. *Significant at p < .05 level; ** Significant at p < .01 level; *** Significant at p < .001 level.

Appendix N Robustness check: Admissions assessments exclusion
(Indicates differences in the fixed effects model)
Dependent variable: Isolation precautions
The final regression sample included 9,700 unique nursing homes, 82,057 observations

	Facility-Level Fixed Effects		
Predictor	***B***	**SE**	***P***
Clinical Characteristics			
Activities of Daily Living: Eating[a]			
Supervision needed	-0.0058	0.0029	0.05
Support needed/activity did not occur	0.0082	0.0038	0.03
Facility Characteristics			
Staffing: Registered Nurses[b]			
(Ref: 2.08-2.31)			
0.00-0.23	0.1023	0.0447	0.02
1.62-1.85	0.0606	0.0433	0.16
Other Predictors			
Quarter of assessment			
(time trend, ref: Q4 2013)			
Q4 2010	0.093	0.0053	< .001
Q3 2011	0.047	0.0047	< .001
Q2 2012	0.0312	0.0046	< .001
Q3 2012	0.0232	0.0046	< .001

Note: Adjusted R^2: .03. [a]Activities of daily living reference categories are "independent"; [b]Measured in full-time equivalent hours per resident per day; Highest 1% of values excluded as outliers. Standardized and divided into 10 categories by value, with highest as the reference.

Interpretation: Eliminating admissions assessments makes support needed with eating activities of daily living is a weaker predictor of isolation and needing supervision becomes inversely related to isolation precautions use. Registered nurse staffing of 1.62-1.85 full time equivalents (FTE) per hour per day is no longer inversely correlated vs. the highest level of staffing and 0.00-0.23 FTE per hour per day has a positive association compared to the highest staffing level.

Appendix O Robustness check: State fixed effects
Dependent variable: Isolation precautions
The final regression sample included 50 states and 188,059 observations

Predictor	Facility-Level Fixed Effects B	SE	P
Resident Demographics			
Race (ref: *White, Not Hispanic)*			
Unknown Race/Ethnicity	0.1573	0.0264	< .001
Clinical Characteristics			
Behavioral Problem: Verbal[a]			
Occurred ≥4 of last 7 days	0.0279	0.0077	< .001
Indwelling Catheter	0.0163	0.0019	< .001
Facility Characteristics			
Chain membership	-0.0325	0.0017	< .001
Facility Size *(*number of beds*)*	-0.0603	0.0048	< .001
Occupancy Rate[b] *(ref: 95.1-100%)*			
Continuous	0.1848	0.0395	< .001
Squared	-0.1957	0.0267	< .001
Ownership Status *(ref: For-profit)*			
Government	0.0236	0.0044	< .001
Not for-profit	0.0046	0.002	0.02
Staffing: Registered Nurses[c,d,e] *(ref: 2.08-2.31)*			
0.00-0.23	0.0623	0.0156	< .001
0.23-0.46	0.0423	0.0135	< .001
0.46-0.69	0.0343	0.0133	0.01
0.69-0.92	0.0314	0.0133	0.02
1.85-2.08	0.0296	0.0162	0.07
Staffing: Licensed Practical Nurse[c,d]			
Continuous	-0.1504	0.0199	< .001
Squared	0.1708	0.0215	< .001
Staffing: Certified Nurse Aide[c,d]			
Squared	0.0371	0.0282	0.19
Location Characteristics			
Market competition[f] *(in county, ref: 8050-10000)*			
2,003.4-4,000.0	0.0265	0.009	< .001
Other Predictors			
Quarter of assessment *(time trend, ref: Q4 2013)*			
Q4 2010	0.0929	0.0041	< .001

Note: Adjusted R^2: .03. [a]Behavioral problem-related items reference "behavior not exhibited"; [b]Capped at 1 (100% occupancy); [c]Highest 1% of values excluded as outliers; [d]Measured in full-time equivalent hours per resident per day; [e]Standardized and divided into 10 categories by value, with highest as the reference; [f]Herfindahl Index, standardized and divided into 5 categories by value, with highest as the reference.

Interpretation: Verbal behavioral problems (>4 days of past 7) became positively associated compared to behavior not exhibited (perhaps behavioral problems are acting a proxy for a worse infection and the state fixed effects reflect the culture/ perceptions around severity by state). Chain membership and ownership now associated with isolation precautions. Facility size has a much weaker relationship. Nursing homes are now more likely to use isolation precautions at lower registered nurses staffing levels

(compared to the highest staffing level). Larger betas for licensed practical nurses staffing and smaller beta for certified nurse aides.

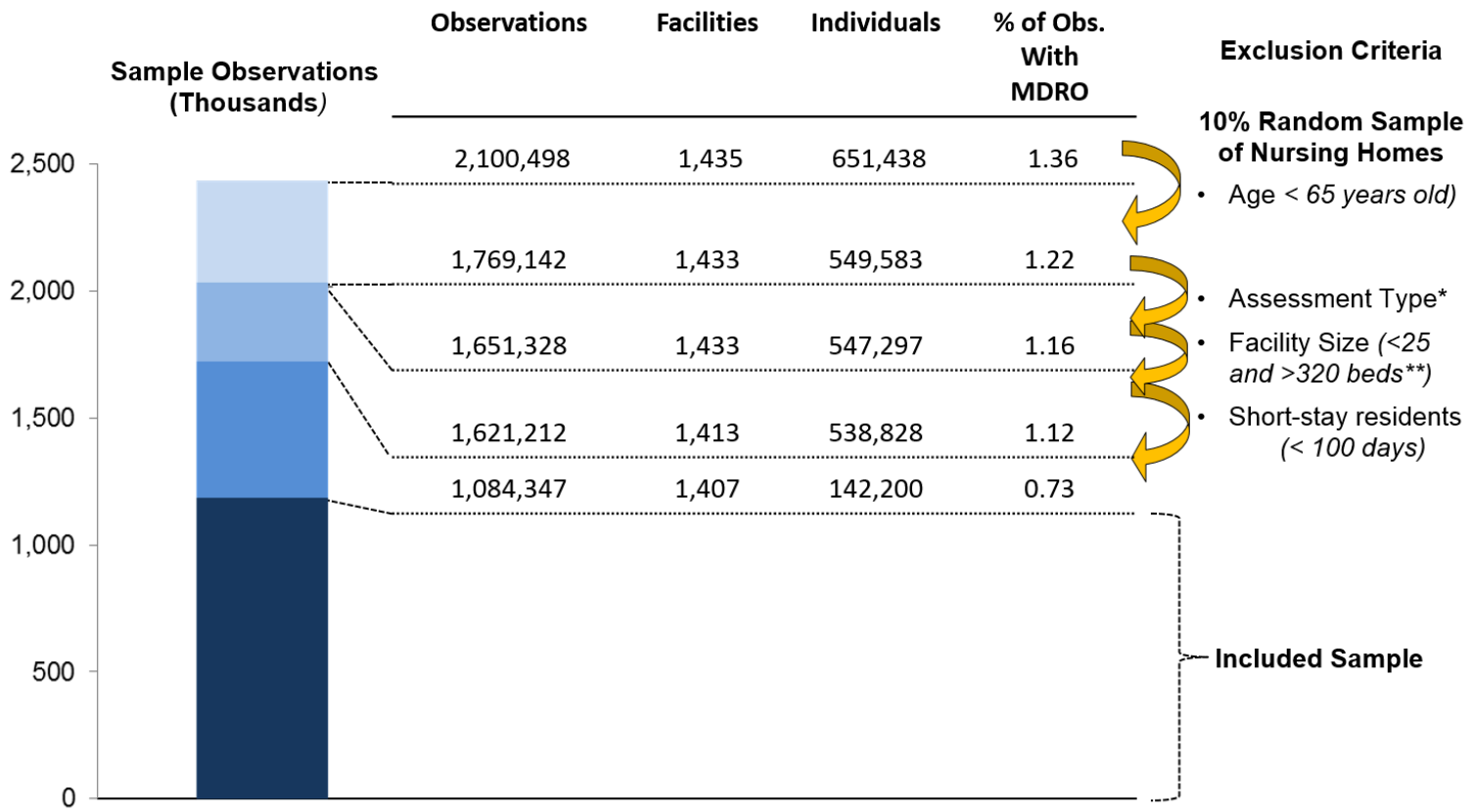
Appendix P Robustness check: Centers for Medicare and Medicaid regional fixed effects**.**
Dependent variable: Isolation precautions
The final regression sample included 10 regions and 188,059 observations

Predictor	Facility-Level Fixed Effects *B*	SE	*P*
Resident Demographics			
Race (ref: *White, Not Hispanic)*			
American Indian or Alaskan Native	-0.0547	0.0131	< .001
Black, Not Hispanic	0.0129	0.0028	< .001
Clinical Characteristics			
Behavioral problem: Verbal[a]			
Occurred ≥4 of last 7 days	0.0275	0.0078	< .001
History of MDRO-positive MDS Assessment			
(before current assessment)	-0.025	0.0022	< .001
Indwelling catheter	0.0161	0.0019	< .001
Long-stay Status *(> 100 days in facility)*	-0.0118	0.0025	< .001
Facility Characteristics			
Chain membership	-0.0337	0.0017	< .001
Citation on last inspection: *Infection control*	0.0106	0.0016	< .001
Citation on last inspection: *Care quality*	0.0027	0.0017	0.10
Facility size *(*number of beds*)*	-0.0486	0.0046	< .001
Occupancy rate[b] *(ref: 95.1-100%)*			
Continuous	0.2841	0.0393	< .001
Squared	-0.2983	0.0266	< .001
Ownership Status *(ref: For-profit)*			
Government	-0.0197	0.0143	0.17
Not for-profit	0.0239	0.0086	0.01
Staffing: Registered Nurses[c,d,e] *(ref: 2.08-2.31)*			
0.00-0.23	0.054	0.0157	< .001
0.23-0.46	0.0375	0.0135	0.01
1.85-2.08	0.0406	0.0163	0.01
Top 1% of RN staffing levels	-0.0173	0.0124	0.16
Staffing: Licensed Practical Nurse[c,d]			
Continuous	-0.1757	0.019	< .001
Squared	0.1922	0.021	< .001
Staffing: Certified Nurse Aide[c,d]			
Continuous	-0.0666	0.0285	0.02
Squared	0.0497	0.0282	0.08
Top 1% of Aide staffing levels	0.0218	0.0166	0.19
Location Characteristics			
Elderly per square mile[d,e] *(65+ years, in county, ref: 359.33-396.13)*			
158.57-197.96	-0.1104	0.0092	< .001
Other Predictors			
Quarter of assessment *(time trend, ref: Q4 2013)*			
Q4 2010	0.0903	0.0041	< .001

Note: Adjusted R^2: .04. [a]Behavioral problem-related items reference "behavior not exhibited"; [b]Capped at 1 (100% occupancy); [c]Measured in full-time equivalent hours per resident per day; [d]Highest 1% of values excluded as outliers, then standardized. [e]Divided into 10 categories by value, with highest as the reference.

Interpretation: Verbal behavioral problems (>4 days of past 7) became positively associated compared to behavior not exhibited (perhaps behavioral problems are acting a proxy for a worse infection and the state fixed effects reflect the culture/ perceptions around severity by region). History of multidrug resistant organism (MDRO) infection has a stronger negative relationship, which again can be due to cultural differences/perceptions (of quality of life) by region. Indwelling catheter is a stronger positive predictor and long-stay status is a stronger negative predictor. Chain membership (negative), infection control-related and quality citations (positive) and ownership now associated with isolation precautions. Facility size has a much weaker relationship. NHs are now more likely to use isolation precautions at lower registered nurse (RN) staffing levels (compared to the highest staffing level). This robustness check has larger betas for licensed practical nurse (LPN) staffing and smaller beta for certified nurse aides (CNAs). The top 1% indicators of staffing variables (RN, LPNs and CNAs) are no longer significant.

Appendix Q Sampling overview of random 10% nursing home sample



*Observations that are a significant change in status assessment or missing assessment type were excluded.
** 98th percentile is included

Appendix R Multidrug-resistant organisms infection predictors by outcome definition (current vs. future MDRO infection)

	All Assessments (N=1,084,347)		MDRO Infection On Next Assessment (n=6,397)		No MDRO Infection On Next Assessment (n=935,655)			Current MDRO Infection (n=7,865)		No Current MDRO Infection (n=1,076,351)		*P*
Resident Demographics	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***	**Mean**	**SD**	**Mean**	**SD**	***P***
Age in years	83.56	8.57	81.59	8.67	83.46	8.55	.132	81.58	8.73	83.58	8.57	< .001
	N	**%**	**N**	**%**	**N**	**%**	***P***	**N**	**%**	**N**	**%**	***P***
Female gender	788,084	72.68	4,123	64.45	683,181	73.02	< .001	5,045	64.14	782,941	72.74	< .001
Race												
American Indian or Alaskan Native	4,538	0.42	31	0.48	3,882	0.41	< .001	39	0.50	4,498	0.42	.579
Asian	13,603	1.25	41	0.64	11,731	1.25	< .001	54	0.69	13,549	1.26	.001
Black	119,049	10.98	530	8.29	103,542	11.07	.642	674	8.57	118,372	11.00	< .001
Hispanic	53,466	4.93	328	5.13	46,209	4.94	.819	406	5.16	53,059	4.93	0.602
Native Hawaiian/ Pacific Islander	2,631	0.24	17	0.27	2,251	0.24	.682	17	0.22	2,614	0.24	.785
White	875,911	80.78	5,350	83.63	754,684	80.66	.534	6,554	83.33	869,234	80.76	.001
Clinical Characteristic	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***P***	**Mean**	**SD**	**Mean**	**SD**	***P***
Activities of daily living support long-form score *(0-28)*[a]	16.88	7.17	18.83	6.10	16.69	7.20	.576	19.38	5.79	16.86	7.18	< .001
	N	**%**	**N**	**%**	**N**	**%**	***P***	**N**	**%**	**N**	**%**	***P***
Admissions assessment	77416	7.14	799	12.49	76610	8.19	.028	1,088	13.83	76,322	7.09	< .001
Antibiotic exposure	61502	12.74	847	31.50	48683	12.78	.537	1,642	46.54	59,853	12.49	< .001
Dementia diagnosis	677686	62.52	3164	49.50	582146	62.24	.002	3,955	50.31	673,712	62.61	< .001
Diabetes Mellitus diagnosis	346857	32.00	2837	44.36	297655	31.82	.183	3,551	45.16	343,247	31.90	< .001
Dialysis received in facility	12419	1.15	208	3.26	10112	1.09	< .001	272	3.47	12,146	1.14	< .001

	All Assessments (N=1,084,347)		MDRO Infection On Next Assessment (n=6,397)		No MDRO Infection On Next Assessment (n=935,655)			Current MDRO Infection (n=7,865)		No Current MDRO Infection (n=1,076,351)		
	N	**%**	**N**	**%**	**N**	**%**	***P***	**N**	**%**	**N**	**%**	***P***
History of MDRO infection	7742	0.71	2080	32.56	4133	0.44	< .001	3,605	45.93	4,137	0.38	< .001
Indwelling catheter	94676	8.73	1875	29.31	79259	8.47	< .001	2,773	35.26	91,880	8.54	< .001
Understood	583391	53.80	3759	58.76	509248	54.43	.547	4,594	58.41	578,704	53.77	< .001
Wandering in past 7 days	74475	6.88	201	3.15	65607	7.02	.387	234	2.99	74,232	6.91	< .001
Wounds	108630	10.02	1937	30.28	89465	9.56	.001	2,808	35.71	105,809	9.83	< .001
Other Predictors												
Quarter of assessment *(time trend)*	--	--	--	--	--	--	.225	--	--	--	--	< .001
Month of assessment *(seasonality)*	--	--	--	--	--	--	.581	--	--	--	--	< .001

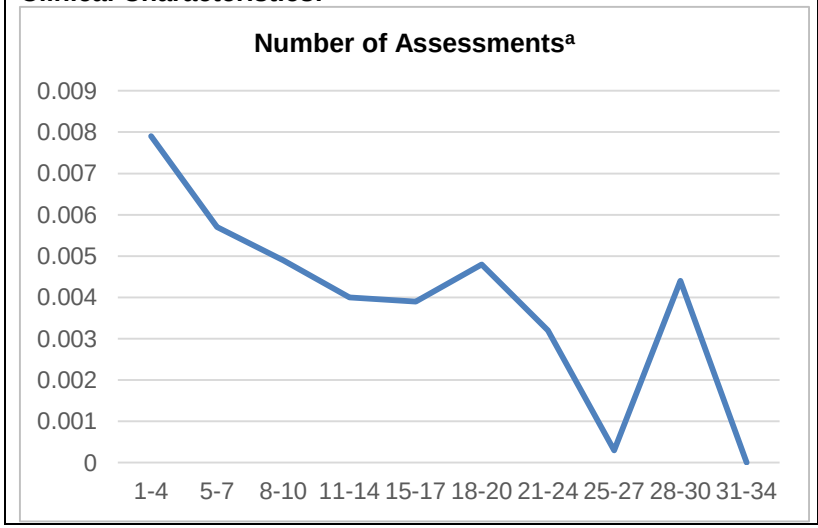
Notes: Representing 142,200 unique residents in 1,407 facilities. [a]Self performance on all activities is zero on the activities of daily living support long-form score and higher score indicates more support is needed. MDRO = multidrug resistant organism; SD = standard deviation; CMS = Centers for Medicare and Medicaid Services.

Appendix S Functional forms of association between continuous variables and probability of multidrug resistant organism (MDRO) infection

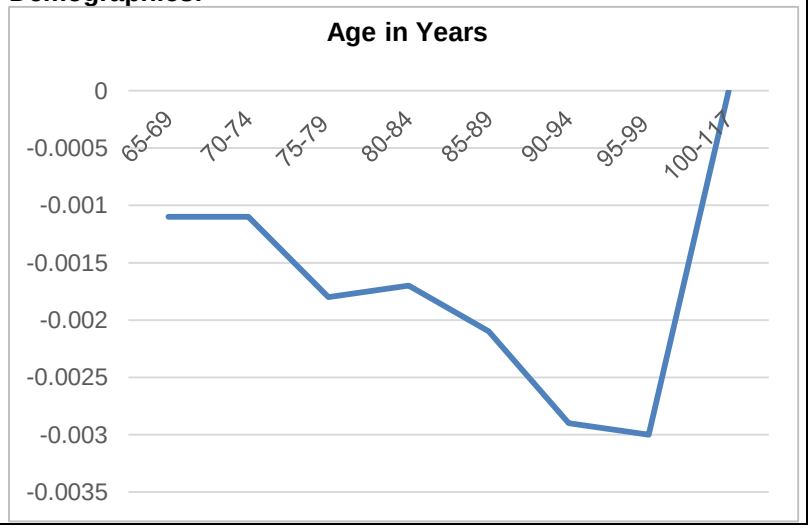
(preliminary main effects multiple variable regression with facility-level clustered robust standard errors)

Relationship with MDRO Infection

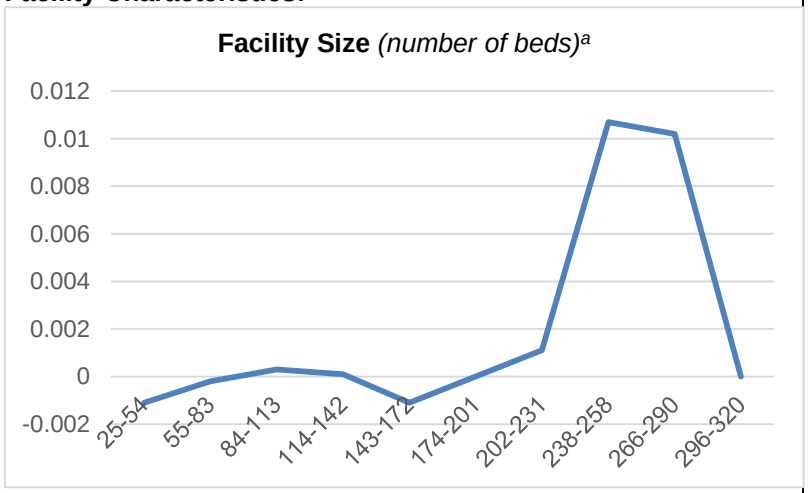
Clinical Characteristics:



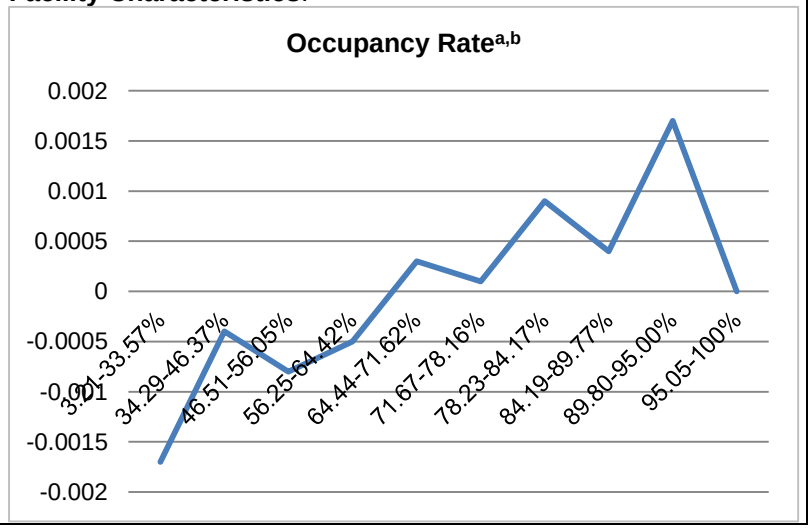
Demographics:



Facility Characteristics:



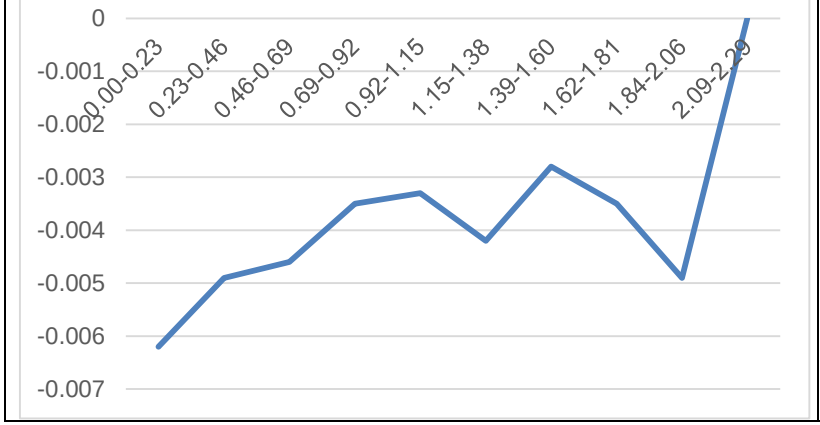
Facility Characteristics:



Facility Characteristics:

Staffing: Registered Nurses[a,c]

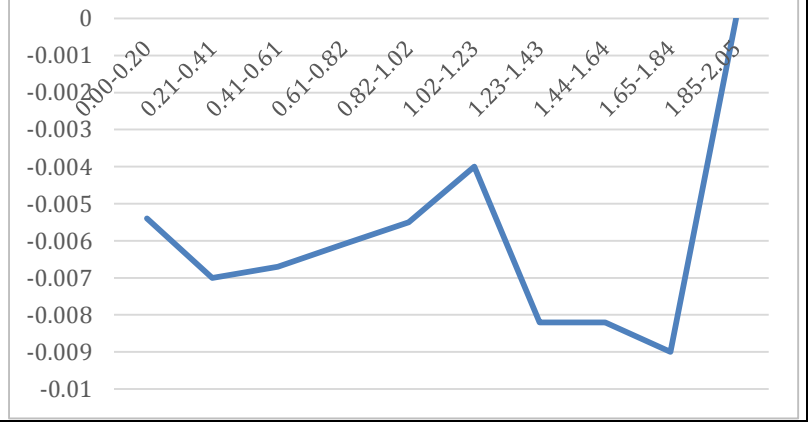
(Full time equivalent hours per resident per day)



Facility Characteristics:

Staffing: Licensed Practical Nurse[a,b]

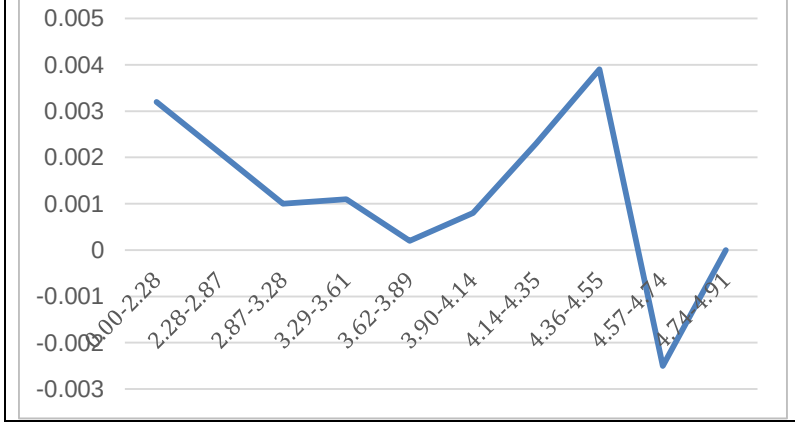
(Full time equivalent hours per resident per day)



Facility Characteristics:

Staffing: Certified Nurse Aide[a,c]

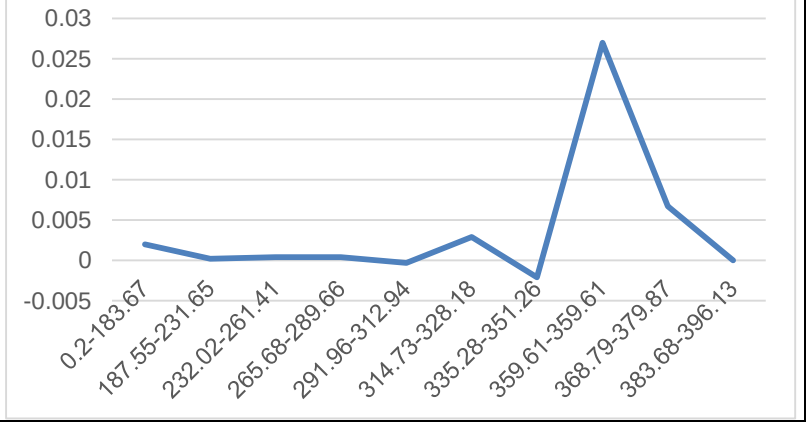
(Full time equivalent hours per resident per day)



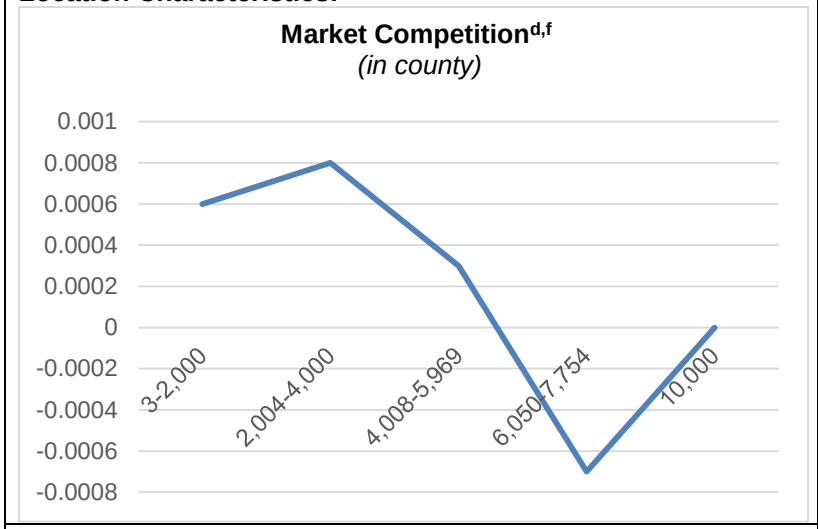
Location Characteristics:

Elderly per Square Mile[a,c]

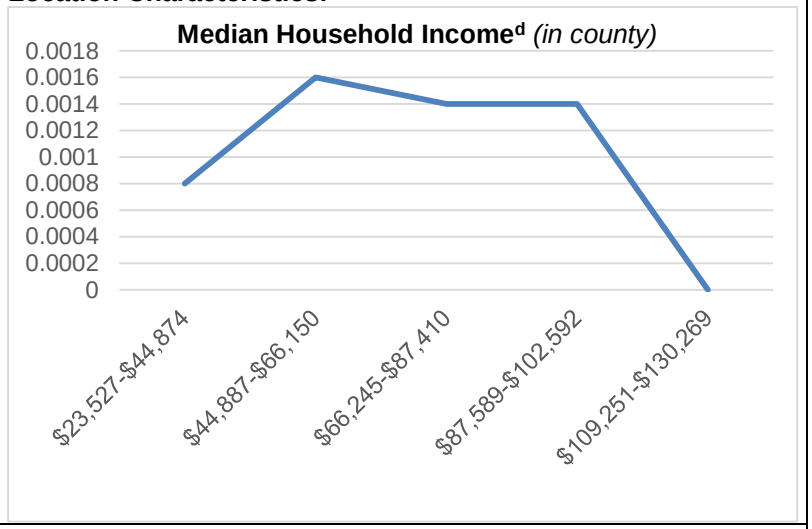
(65+ years, in county)



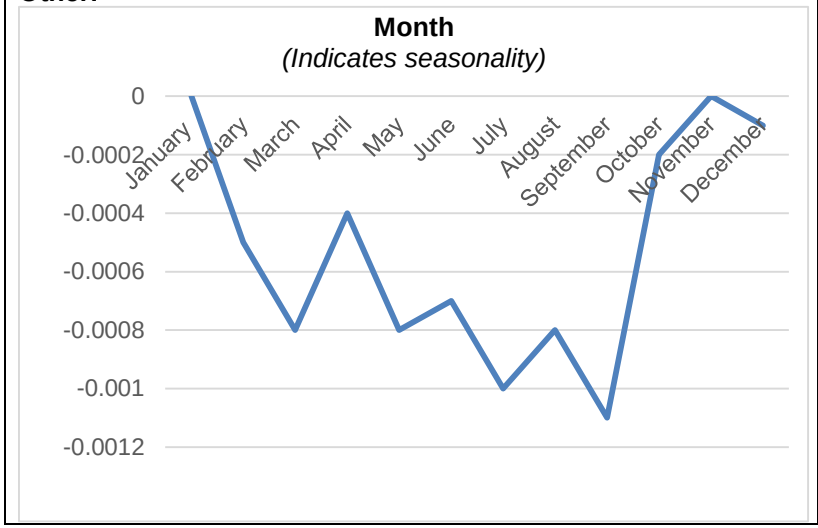
Location Characteristics:



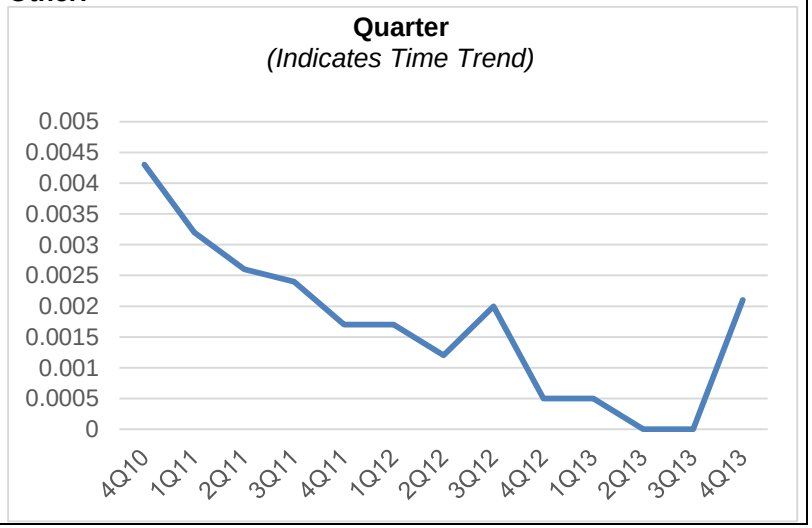
Location Characteristics:



Other:



Other:



Note: All categories are comprehensive within the final sample. [a]Standardized and divided into 10 categories by value, with highest as the reference; [b]Capped at 1 (100% occupancy); [c]Highest 1% of values excluded as outliers; [d]Standardized and divided into 5 categories by value, with highest as the reference. [f]Herfindahl index indicates complete market share of beds in the county and lower number indicates a more competitive market.

Appendix T Results of full multiple variable regressions

(1) with facility-level clustered robust standard errors and (2) facility-level fixed effects.
Dependent variable: Multidrug resistant infection on the current assessment
The final regression sample included 1,404 unique Nursing Homes, 931,569 observations.

	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
Predictor (present on the previous assessment)	***B***	**SE**	***P***	***B***	**SE**	***P***
Clinical Characteristics						
Activities of daily living: Bed mobility[a]						
Support needed/activity did not occur	0.0008	0.0004	.05	0.0006	0.0004	.15
Activities of daily living: Dressing[b]						
Supervision needed	-0.0006	0.0004	.11	-0.0004	0.0004	.39
Support needed/activity did not occur	0.0001	0.0005	.9	0.0002	0.0005	.68
Activities of daily living: Eating[b]						
Supervision needed	-0.0004	0.0003	.19	0.0002	0.0003	.47
Support needed/activity did not occur	0.0001	0.0004	.88	0.0001	0.0002	.58
Activities of daily living: Hygiene[b]						
Supervision needed	0.0002	0.0004	.56	-0.0002	0.0004	.58
Support needed/activity did not occur	0.0005	0.0005	.3	-0.0007	0.0004	.12
Activities of daily living: Locomotion[a]						
Support needed/activity did not occur	0.0005	0.0003	.05	0.0006	0.0002	.02
Activities of daily living: Tolieting[a]						
Support needed/activity did not occur	0.0005	0.0004	.24	0.0006	0.0004	.13
Activities of daily living: Transfer[a]						
Support needed/activity did not occur	-0.0002	0.0004	.6	0.0003	0.0004	.53
Admissions assessment	-0.0012	0.001	.24	-0.0016	0.0007	.03
Antibiotics Received *(in past 7 days or since admission/entry or reentry)*	0.0051	0.0007	< .001	0.0048	0.0004	< .001
Antibiotics missing	0.0002	0.0003	.55	0.0002	0.0003	.53
Dementia diagnosis, Alzheimer's	-0.001	0.0003	< .001	-0.0008	0.0002	< .001
Dementia diagnosis, not Alzheimer's	-0.0005	0.0002	.05	-0.0005	0.0002	.01
Diabetes Mellitus diagnosis	0.0032	0.0006	< .001	0.003	0.0004	< .001
Dialysis received in facility	0.0055	0.0018	< .001	0.0052	0.0008	< .001
History of MDRO-positive MDS assessment *(before current)*	0.324	0.0253	< .001	0.3094	0.001	< .001

Predictor (present on the previous assessment)	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
Indwelling devices						
Indwelling catheter	0.0107	0.0012	< .001	0.0105	0.0004	< .001
Intermittent catheter	0.0107	0.0039	.01	0.0101	0.0015	< .001
Intravenous medication	0.0217	0.0022	< .001	0.0215	0.0008	< .001
Ostomy	0.0041	0.0014	< .001	0.004	0.0007	< .001
Tracheostomy	0.011	0.0057	.05	0.0142	0.0015	< .001
Number of assessments per resident[c] *(ref: 31-34 assessments)*						
1-4	0.0079	0.0021	< .001	0.0092	0.0058	.12
5-7	0.0057	0.0021	.01	0.0072	0.0058	.22
8-10	0.0049	0.0021	.02	0.0062	0.0058	.29
11-14	0.004	0.0021	.05	0.0054	0.0058	.36
15-17	0.0039	0.0022	.08	0.005	0.0058	.39
18-20	0.0048	0.0024	.05	0.0061	0.0059	.3
21-24	0.0032	0.0027	.24	0.0042	0.0059	.48
25-27	0.0003	0.0025	.92	0.0019	0.0061	.76
28-30	0.0044	0.0049	.38	0.0034	0.0065	.61
Ability to make self understood *(ref: Is understood)*						
Usually	0	0.0003	.93	-0.0002	0.0002	.38
Sometimes/rarely/never	-0.0004	0.0004	.35	-0.0003	0.0003	.22
Wandering *(ref: No wandering)*						
1-3 days of last week	-0.0005	0.0004	.27	-0.0005	0.0005	.28
4-6 days of last week	-0.0009	0.0006	.13	-0.0009	0.0007	.23
Daily wandering in last week	-0.0008	0.0004	.03	-0.0005	0.0005	.3
Wounds						
Burn (of skin)	-0.0023	0.0046	.61	-0.0024	0.0034	.47
Diabetic foot ulcer	0.0148	0.0042	< .001	0.015	0.0014	< .001
Non-diabetic open lesion on foot	0.0031	0.0018	.09	0.0028	0.001	.01
Pressure ulcer	0.0077	0.0009	< .001	0.0076	0.0004	< .001
Surgical wound	0.0097	0.0014	< .001	0.0097	0.0006	< .001
Venous-Arterial Ulcer	0.0115	0.0017	< .001	0.0116	0.0007	< .001
Open lesions other than ulcers, rashes and cuts	0.0048	0.0011	< .001	0.005	0.0006	< .001
Facility characteristics						
Chain membership	-0.0006	0.0006	.29	0.0001	0.0005	.8
Deficiency citation						
Infection control	0.0005	0.0005	.26	-0.0002	0.0002	.3
Care quality	0.0003	0.0005	.59	0.0002	0.0002	.31
Facility size[c] *(*number of beds, *ref: 296-320)*						
25-54	-0.0012	0.0014	.38	0.0016	0.0058	.78

Predictor (present on the previous assessment)	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
55-83	-0.0002	0.0014	.87	-0.0011	0.0053	.84
84-113	0.0002	0.0013	.86	-0.0041	0.0052	.43
114-142	0.0001	0.0013	.96	-0.0032	0.005	.52
143-172	-0.0011	0.0014	.43	-0.0034	0.005	.5
174-201	0	0.0014	1	-0.0007	0.0044	.87
202-231	0.0011	0.0018	.54	-0.0068	0.0044	.12
238-258	0.0107	0.0066	.1	0.0008	0.0032	.8
266-290	0.0102	0.0067	.13	0.0155	0.0033	< .001
Occupancy rate[c,d] *(ref: 95.05-100%)*						
3.21-33.57%	-0.0018	0.0022	.42	-0.0007	0.0037	.85
34.29-46.37%	-0.0004	0.0012	.76	-0.0006	0.0017	.74
46.51-56.05%	-0.0008	0.0008	.3	-0.0009	0.0011	.43
56.25-64.42%	-0.0005	0.0009	.59	-0.0015	0.0009	.09
64.44-71.62%	0.0003	0.0009	.77	-0.0002	0.0007	.76
71.67-78.16%	0.0001	0.0007	.91	-0.0008	0.0006	.18
78.23-84.17%	0.0009	0.0007	.19	0.001	0.0005	.05
84.19-89.77%	0.0004	0.0006	.52	0	0.0004	.98
89.80-95.00%	0.0017	0.0008	.03	0.0002	0.0004	.54
Ownership status *(ref: For-profit)*						
Government	0.0022	0.0027	.42	0.0019	0.0016	.22
Not for-profit	0.0012	0.0009	.19	0.0006	0.0009	.5
Staffing: Registered nurses[c,e,f] *(ref: 0.46-0.69)*						
0.00-0.23	-0.0062	0.0052	.23	-0.0033	0.0055	.54
0.23-0.46	-0.005	0.0052	.34	-0.0013	0.0055	.81
0.69-0.92	-0.0046	0.0052	.37	-0.0012	0.0054	.82
0.92-1.15	-0.0035	0.0053	.51	-0.001	0.0054	.86
1.15-1.38	-0.0034	0.0052	.52	-0.0013	0.0054	.82
1.39-1.60	-0.0042	0.0052	0.42	-0.0011	0.0055	0.84
1.62-1.81	-0.0028	0.0054	.6	-0.001	0.0055	.85
1.84-2.06	-0.0035	0.0061	.56	-0.0022	0.0058	.71
2.09-2.29	-0.0049	0.0066	.46	-0.007	0.006	.25

Predictor (present on the previous assessment)	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
Top 1%of RN Staffing	0.0019	0.0018	.31	0.001	0.003	.75
Staffing: Licensed practical nurse[c,e,f] *(ref: 0.61-0.82)*						
0.00-0.20	-0.0055	0.005	.27	-0.006	0.0024	.01
0.21-0.41	-0.007	0.0049	.15	-0.0059	0.0023	.01
0.41-0.61	-0.0067	0.0049	.17	-0.0062	0.0022	.01
0.82-1.02	-0.0061	0.0048	.21	-0.0066	0.0022	< .001
1.02-1.23	-0.0055	0.0048	.26	-0.0064	0.0022	< .001
1.23-1.43	-0.004	0.0049	.4	-0.0063	0.0022	< .001
1.44-1.64	-0.0082	0.0049	.1	-0.0072	0.0023	< .001
1.65-1.84	-0.0083	0.0049	.09	-0.0072	0.0024	
1.85-2.05	-0.009	0.0052	.08	-0.0083	0.003	.01
Top 1% of LPN Staffing	-0.0017	0.0017	.34	0.0018	0.002	.37
Staffing: Certified nurse aide[c,e,f] *(ref: 1.96-2.45)*						
0.00-0.48	0.0032	0.0027	.24	0.0082	0.0036	.02
0.5-0.96	0.0021	0.0026	.41	0.0087	0.0035	.01
0.99-1.47	0.0011	0.0026	.67	0.0071	0.0035	.04
1.47-1.96	0.0011	0.0027	.68	0.0094	0.0036	.01
2.45-2.94	0.0003	0.0028	.92	0.0091	0.0036	.01
3.90-4.14	0.0009	0.0034	.8	0.0111	0.0038	< .001
3.44-3.93	0.0024	0.0036	.51	0.0086	0.0041	.04
3.93-4.41	0.0039	0.0036	.27	0.0076	0.0038	.04
4.42-4.91	-0.0025	0.0034	.46	0.0021	0.0055	.7
Top 1% of CNA staffing	-0.0032	0.0013	.01	-0.0013	0.0018	.47
Resident demographics						
Age in years *(ref: 100-117)*						
65-69	-0.0009	0.0006	.14	-0.001	0.0004	.01
70-74	-0.0005	0.0005	.31	-0.0009	0.0004	.02
75-79	-0.001	0.0005	.06	-0.0013	0.0004	< .001
80-84	-0.0007	0.0005	.19	-0.001	0.0004	.01
85-89	-0.001	0.0005	.06	-0.0014	0.0004	< .001
90-94	-0.0018	0.0006	< .001	-0.0021	0.0005	< .001
95-99	-0.0018	0.001	.06	-0.0021	0.0008	.01
Female gender	-0.0007	0.0003	0.03	0.0009	0.0002	< .001

Predictor (present on the previous assessment)	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
Race (ref: *White, Not Hispanic)*						
American Indian or Alaskan Native	0.0017	0.0021	0.44	0.0002	0.0015	0.87
Asian	-0.0028	0.0011	0.01	-0.0014	0.0009	.13
Black, not Hispanic	-0.0019	0.0004	< .001	-0.001	0.0003	< .001
Native Hawaiian/ Pacific Islander	-0.0006	0.0026	0.83	0.0012	0.0017	0.47
Unknown, not Hispanic	0.0002	0.0009	.8	-0.0002	0.0007	.82
Black, Hispanic	-0.0049	0.0015	< .001	0.0029	0.0116	.8
Hispanic, Unknown Race	-0.0041	0.002	.04	-0.003	0.0032	.35
Unknown Race/Ethnicity	-0.0005	0.0009	.56	-0.0007	0.0005	.12
Location Characteristics						
Elderly per square mile[c,f] *(65+ years, in county, ref: 383.68-396.13)*						
0.2-183.67	0.0019	0.0019	.32	0.0596	0.0078	< .001
187.55-231.65	0.0001	0.002	.95	0.0607	0.0075	< .001
232.02-261.41	0.0003	0.002	.87	0.061	0.0074	< .001
265.68-289.66	0.0003	0.0026	.9	0.0589	0.0071	< .001
291.96-312.94	-0.0004	0.0021	.84	0.0573	0.007	< .001
314.73-328.18	0.0029	0.0057	.61	0.014	0.0027	< .001
335.28-351.26	-0.0021	0.003	.49	0	.	.
359.61-359.61	0.027	0.0142	.06	0.0241	0.0068	< .001
368.79-379.87	0.0067	0.0028	.02	0.0058	0.0021	< .001
Market Competition[g,h] *(in county, ref: 10,000)*						
3-2,000	0.0006	0.0008	.42	0.0015	0.0012	.22
2,004-4,000	0.0008	0.0008	.36	0.0008	0.001	.44
4,008-5,969	0.0003	0.0009	.75	0.0011	0.0009	.22
6,050-7,754	-0.0007	0.0008	.36	-0.0013	0.0012	.28
Median household income[g] *(in county, ref: $ 109,251- $130,268)*						
$23,528- $44,874	0.0013	0.0026	.63	0.0062	0.0037	.09
$44,887-$66,150	0.002	0.0023	.39	0.0079	0.0036	.03
$66,245-$87,410	0.0017	0.0023	.46	0.009	0.0033	.01
$87,589- $102,592	0.0015	0.0025	.55	0	.	.
Other Predictors						
Quarter of assessment *(time trend, ref: Q4 2013)*						
Q4 2010	0.0044	0.0015	< .001	0.0038	0.001	< .001
Q1 2011	0.0029	0.0013	.02	0.0026	0.001	.01
Q2 2011	0.0022	0.0012	0.08	0.0019	0.001	.06
Q3 2011	0.0016	0.0012	0.2	0.0013	0.001	.19
Q4 2011	0.0018	0.0012	.14	0.0015	0.001	.12

Predictor (present on the previous assessment)	(1) Facility clustered SEs			(2) Facility-Level Fixed Effects		
	B	**SE**	***P***	***B***	**SE**	***P***
Q1 2012	0.0015	0.0012	.24	0.0012	0.001	.22
Q2 2012	0.0007	0.0012	.55	0.0005	0.001	.61
Q3 2012	0.0012	0.0012	.32	0.001	0.001	.3
Q4 2012	0.0005	0.0012	0.64	0.0004	0.001	0.7
Q1 2013	0.0002	0.0011	0.85	0.0001	0.001	0.89
Q2 2013	-0.0005	0.0012	.69	-0.0006	0.001	.56
Q3 2013	-0.0008	0.0011	.46	-0.001	0.001	.3
Interaction terms						
Age and Diabetes	-0.0006	0.0001	< .001	-0.0006	0.0001	< .001
Admissions assessment and median household income	0.0076	0.0036	.04	0.0083	0.0025	< .001
Admissions assessment and elderly per square mile	-0.0029	0.002	.14	-0.0022	0.0013	.08
Constant	0.001	-0.0007	.0089	0.94	-0.0683	.013
N		931569			931569	
ll	1063185				1069032	

Note: Adjusted R^2: Model 1) .11 Model 2) .10. Model 2 C-statistic: .78. All categories are comprehensive within the final sample. Activities of daily living reference categories are [a]"independent"/""supervision needed" or [b] "independent"; [c]Standardized and divided into 10 categories by value, with highest as the reference; [d]Capped at 1 (100% occupancy); [e]Measured in full-time equivalent hours per resident per day; [f]Highest 1% of values excluded as outliers; [g]Standardized and divided into 5 categories by value, with highest as the reference; [h]Herfindahl Index.

Appendix U Joint contribution tests from full linear probability model with facility fixed effects.
Dependent Variable: multidrug resistant organism infection

Predictor (present on the previous assessment)	Joint Contribution to M2 F-score	Probability > F
Resident Demographics		
Age in Years	3.44	.0011
Race/ Ethnicity	1.70	.0825
Clinical Characteristics		
Activities of daily living:		
Dressing	1.64	.1939
Eating	0.31	.7335
Hygiene	1.56	.2109
Dementia diagnosis	9.73	.0001
Indwelling Devices	337.65	< .001
Number of assessments per resident	22.19	< .001
Ability to make self understood	0.92	.3968
Wandering	1.08	.3559
Wounds	186.20	< .001
Facility Characteristics		
Facility size (number of beds)	3.82	.0001
Occupancy rate[1]	2.19	.0196
Ownership Status	0.82	.4406
Staffing[2]		
Registered Nurses	1.26	.2523
Licensed Practical Nurses	1.57	.1165
Certified Nurse Aides	3.52	.0002
Location Characteristics		
Elderly per square mile[2] *(65+ years, in county)*	11.32	< .001
Market competition[3] *(in county)*	1.83	.1200
Median household income *(in county)*	5.11	.0016
Other Predictors		
Quarter of assessment *(time trend)*	13.47	< .001
Interaction terms		
Admissions vs. county-level variables	5.61	.0037

Note: Adjusted R^2: .10, C-statistic: .78.[1]Capped at 1 (100% occupancy); [2]Highest 1% of values excluded as outliers; [3]Herfindahl Index.

Appendix V Robustness check: Definition of long-stay residents
Dependent variable: Multidrug resistant infection on the current assessment
The final regression sample included 842,903 observations.

	Facility-Level Fixed Effects		
Predictor (present on the previous assessment)	***B***	**SE**	***P***
Location Characteristics			
Elderly per square mile[1] *(65+ years, in county, ref: 383.68-396.13)*			
187.55-231.65	0.0012	0.0019	.54
232.02-261.41	0.0007	0.0022	.74
265.68-289.66	-0.0017	0.0031	.59
291.96-312.94	-0.0034	0.0034	.31
314.73-328.18	-0.0551	0.0073	< .001
Median household income[2] *(in county, ref: $ 109,251- $130,268)*			
$66,245-$87,410	0.0013	0.0016	.44

Note: Adjusted R^2: .10. [1]Standardized and divided into 10 categories by value, with highest as the reference. Highest 1% of values excluded as outliers; [2]Standardized and divided into 5 categories by value, with highest as the reference.

Interpretation: These results are robust with regard to clinical and facility predictors.

Appendix W Robustness check: Admissions assessment exclusion
Dependent variable: Multidrug resistant organism infection on the current assessment
The final regression sample included 854,615 observations.

Predictor (present on the previous assessment)	Facility-Level Fixed Effects		
	B	**SE**	***P***
Clinical Characteristics			
Wounds			
Surgical wound	0.0127	0.0008	< .001

Note: Adjusted R^2: .10. All categories are comprehensive within the final sample. Activities of daily living reference categories are [1] "independent"/""supervision needed" or [2] "independent"; [3]Standardized and divided into 10 categories by value, with highest as the reference; [4]Capped at 1 (100% occupancy); [5]Measured in full-time equivalent hours per resident per day; [6]Highest 1% of values excluded as outliers; [7]Standardized and divided into 5 categories by value, with highest as the reference.

Interpretation: Surgical wound(s) was a stronger predictors of MDRO. This is intuitive as most surgical wounds would have healed by the time of a quarterly or annual assessment except those that are complicated (i.e., due to infection).

Appendix X Robustness check: Exclusion of residents with an MDRO infection on the previous assessment**.**

Dependent variable: Multidrug resistant organism infection on the current assessment
The final regression sample included 924,976 observations.

	Facility-Level Fixed Effects		
Predictor (present on the previous assessment)	***B***	**SE**	***P***
Resident Demographics			
Female gender	-0.0003	0.0002	.06
Clinical Characteristics			
Activities of daily living: Locomotion *(ref: independent"/""supervision needed")*			
Support needed/activity did not occur	0	0.0002	.89
Antibiotics Received *(in past 7 days or since admission/entry or reentry)*	0.0022	0.0003	< .001
Antibiotics missing	-0.0008	0.0002	< .001
Diabetes Mellitus diagnosis	0.0019	0.0003	< .001
History of MDRO-positive MDS assessment *(before current assessment)*	0.0936	0.0011	< .001
Indwelling devices			
Indwelling catheter	0.0069	0.0003	< .001
Intermittent catheter code	0.0052	0.0012	< .001
Intravenous medication	0.0078	0.0007	< .001
Tracheostomy	0.0093	0.0012	< .001
Wounds			< .001
Diabetic foot ulcer	0.0089	0.0011	< .001
Pressure ulcer	0.0043	0.0003	< .001
Surgical wound	0.0054	0.0005	< .001
Open lesions other than ulcers, rashes and cuts	0.0021	0.0005	< .001
Facility Characteristics			
Facility size[a] *(*number of beds, *ref: 296-320)*			
266-290	0.006	0.0026	.02
Location Characteristics			
Elderly per square mile[a,b] *(65+ years, in county, ref: 383.68-396.13)*			
0.2-183.67	0.0174	0.0062	< .001
187.55-231.65	0.0196	0.006	< .001
232.02-261.41	0.019	0.0059	< .001
265.68-289.66	0.0162	0.0056	< .001
291.96-312.94	0.013	0.0055	.02
359.61-359.61	0.0019	0.0055	.72
Market competition[c] *(in county, ref: 10,000)*			
4,008-5,969	0.0016	0.0013	.2
Interaction terms			
age_diabetes	-0.0003	0.0001	< .001

Note: Adjusted R^2: .01. All categories are comprehensive within the final sample. [a]Standardized and divided into 10 categories by value, with highest as the reference; [b]Highest 1% of values excluded as outliers; [c]Herfindahl Index, standardized and divided into 5 categories by value, with highest as the reference.

Interpretation: Activities of daily living, receiving antibiotics and having a history of MDRO had weaker or no relationships with MDRO infection. This is not surprising as these factors are likely change with MDRO infection. Wounds and female gender were more predictive, as both represent susceptibility to infection. Antibiotics being missing was inversely related to MDRO infection (which is intuitive because if there was an infection NH staff would be cautious not to miss this item).

Appendix Y Robustness check: State fixed effects
Dependent variable: Multidrug resistant organism infection on the current assessment
The final regression sample included 931,569 observations.

Predictor (present on the previous assessment)	Facility-Level Fixed Effects		
	B	**SE**	***P***
Facility Characteristics			
Deficiency Citation			
Infection control	0.0007	0.0002	< .001
Facility size[a] *(*number of beds, *ref: 296-320)*			
238-258	0.0109	0.0008	< .001
Occupancy rate[a,b] *(ref: 95.05-100%)*			
64.44-71.62%	0.0014	0.0004	< .001
71.67-78.16%	0.0009	0.0004	.02
84.19-89.77%	0.0011	0.0003	< .001
89.80-95.00%	0.002	0.0003	< .001
Location Characteristics			
Elderly per square mile[a,c] *(65+ years, in county, ref: 383.68-396.13)*			
0.2-183.67	0.0026	0.0008	< .001
187.55-231.65	0.0011	0.0008	.17
232.02-261.41	0.0013	0.0009	.14
265.68-289.66	0	0.001	.97
291.96-312.94	-0.0007	0.0011	.52
314.73-328.18	0.0022	0.0015	.13
Market competition[d] *(in county, ref: 10,000)*			
4,008-5,969	-0.001	0.0023	.66

Note: Adjusted R^2: .11. [a]Standardized and divided into 10 categories by value, with highest as the reference; [b]Capped at 1 (100% occupancy); [c]Highest 1% of values excluded as outliers; [d]Herfindahl Index standardized and divided into 5 categories by value, with highest as the reference.

Interpretation: The results are robust excepting the change in infection control citations and occupancy. However, these are not unexpected. Within states, the variation in infection control citations will be more due to nursing homes (NH) practices rather than state policies/inspection practices etc. Further, after having adjusted for NH supply and market demand, higher occupancy should indicate higher quality (as more individuals chose these NHs). Higher occupancy has previously been associated with reduced vancomycin resistant enterococci (VRE) and Methicillin-resistant *Staphlococcus auerus* (MRSA) risk,[90] and here is associated with reduced multidrug resistant organism infection risk.

Appendix Z Robustness check: Centers for Medicare and Medicaid Regions fixed effects**.**
Dependent variable: Multidrug resistant organism infection on the current assessment
The final regression sample included 931,569 observations.

Predictor (present on the previous assessment)	Facility-Level Fixed Effects		
	B	**SE**	***P***
Facility Characteristics			
Deficiency Citation			
Infection control	0.0007	0.0002	< .001
Facility size[a] *(*number of beds, *ref: 296-320)*			
238-258	0.0106	0.0008	< .001
Occupancy rate[a,b] *(ref: 95.05-100%)*			
64.44-71.62%	0.0014	0.0004	< .001
71.67-78.16%	0.0011	0.0004	< .001
84.19-89.77%	0.0012	0.0003	< .001
89.80-95.00%	0.0021	0.0002	< .001
Staffing: Certified nurse aide[a,c,d] *(ref: 4.74-4.91)*			
3.90-4.14	0.0009	0.0029	.76
Location Characteristics			
Elderly per square mile[a,d] *(65+ years, in county, ref: 383.68-396.13)*			
0.2-183.67	0.0009	0.0007	.17
187.55-231.65	0.0001	0.0007	.86
232.02-261.41	-0.0002	0.0008	.82
265.68-289.66	-0.0015	0.0009	.11
291.96-312.94	-0.0028	0.001	< .001
314.73-328.18	0.001	0.0013	.47

Note: Adjusted R^2: .11. All categories are comprehensive within the final sample. [a]Standardized and divided into 10 categories by value, with highest as the reference; [b]Capped at 1 (100% occupancy); [c]Highest 1% of values excluded as outliers; [d]Measured in full-time equivalent hours per resident per day.

Interpretation: The results are robust excepting the change in infection control-related citations and occupancy. However, these are not unexpected. Within regions, the variation in infection control-related citations will be more due to nursing home (NH) practices rather than surveyor training, inspection practices etc. Further, after having adjusted for NH supply and market demand, higher occupancy should indicate higher quality (as more individuals chose these NHs). Higher occupancy has previously been associated with reduced vancomycin resistant enterococci (VRE) and Methicillin-resistant *Staphlococcus auerus* (MRSA) risk,[90] and here is associated with reduced multidrug resistant organism infection risk.

Additional Appendix A. State Focus on Health Care-Associated Infection Prevention in Nursing Homes

The following appendix is a study lead by the author, which characterized the focus of state departments of health on healthcare associated infection reduction in nursing homes. It describes variation in these activities, information and policies, which may influence infection rates in nursing homes across 50 states and the District of Columbia.

Note. The contents of this supplemental appendix are a manuscript accepted for publication by the *American Journal of Infection Control*.

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Abstract

Background

Despite increased focus on healthcare-associated infections (HAI), between 1.6 and 3.8 million HAI occur annually among the vulnerable population residing in U.S. nursing homes (NH). This study characterized state department of health (DOH) activities and policies intended to improve quality and reduce HAI in NH.

Methods

We created a 17-item standardized data collection tool informed by 20 state DOH websites, reviewed by experts in the field and piloted by two independent reviewers (Cohen's Kappa .45-.73). The tool and corresponding protocol were used to systematically evaluate state DOH websites and related links.

Results

Three categories of data were abstracted: 1) consumer-directed information intended to increase accountability of and competition between NH, including mandatory HAI reporting and NH inspection reports, 2) surveyor training for federally-mandated NH inspections and 3) guidance for NH providers to prevent HAI and monitor incidence. Only five states included HAI reporting in NH with differing HAI types and reporting requirements.

Conclusions

State DOH information and activities focused on NH quality and reducing HAI was inconsistent. Systematically characterizing state DOH efforts to reduce HAI in NH is important to interpret the effects of these activities.

Introduction

Healthcare-associated infections (HAI) are a major public health issue. Due to the high cost of this largely preventable problem, there is much attention and investment in the reduction of HAI (1). Infections represent the leading cause of morbidity and mortality among the vulnerable elderly population residing in U.S. nursing homes (NH) (2). An estimated 1.6 to 3.8 million infections occur in U.S. NH each year, resulting in approximately 388,000 deaths (3) with estimated costs of $38-$137 million for antimicrobial therapy and $637 million-$2 billion for hospitalizations (4). Morbidity, mortality and the financial burden associated with HAI in NH is likely to increase as the population of residents is expected to grow from the current 1.7 million (2) to approximately 5.3 million in 2030 (5). Given that Umscheid, et. al. (2011) found that approximately 55-70% of HAI are avoidable in other settings, effective infection control and prevention resources as well as public policies aimed at NH, are likely critical in reducing infections in NH (6).

In 2009, the U.S. Department of Health and Human Services (HHS) published its first National Action Plan to Prevent Health Care-Associated Infections, which identified preventing HAI in hospitals as the phase I priority; fortunately, some HAI rates have improved (7). These improvements are likely a result of a myriad of interventions at the federal, state and institutional level. For example, many states have mandated public reporting of some types of HAI (8). In order to receive preventive health services block funds from the Centers for Disease Control and Prevention (CDC), states were required to submit HAI prevention plans to the HHS in 2010. As a result, each state now has an HAI coordinator who oversees implementation of HAI reduction infrastructure and associated activities as well as raises awareness of HAI in the state (9). The 2013 updated HHS plan identifies long-term care as the next priority setting in which to reduce HAI (7).

There are a number of ways in which a state department of health (DOH) may attempt to improve the quality of care in NH and focus efforts aimed at decreasing HAI. These efforts may be broadly characterized as actions and information targeted at consumers, providers, and surveyors, which may or may not be formally articulated in the state HAI prevention plan.

Consumer-directed information regarding NH quality may allow potential residents and their families to ensure that they select a high quality facility that meets and continues to meet the potential residents' needs (10, 11). In this way, information regarding NH quality, including infection rates, can foster competition and accountability among NH. Theoretically, NH may wish to attract clients through appealing public quality measures, such as lowering rates of urinary tract infections in particular and adapting clinical practice to achieve better quality measures in general (12). Information that may be useful to inform consumer decisions includes: 1) a checklist and/or guidance materials developed for consumers when choosing a NH, 2) a venue to file complaints (i.e., ombudsman) and 3) inspection report data, which may be compiled in a facility report card. Given the theoretical link between quality indicator availability and state DOH focus on NH, it is plausible that consumer information may indicate a focus by state DOH on infection reduction as a component of overall NH quality.

Providers, which include NH clinicians, infection preventionists and administrators, may benefit from state-provided trainings, guidelines and collaboratives that directly address techniques to monitor and reduce HAI in NH. For example, Maryland's Department of Health and Mental Hygiene offered a 3-day basic training course regarding infection control in non-hospital settings (13). Although infection preventionists may also seek information from other websites that specialize in infection control and prevention, such as the CDC's website, the information shown on a state DOH website may be beneficial to raise awareness of resource availability.

State DOH may offer training and other resources to NH surveyors beyond that provided by Centers for Medicare and Medicaid (CMS). Given that these surveyors perform onsite inspections of NH in accordance with CMS regulations, additional training or materials may increase the efficiency and consistency of the annual inspection process, which includes evaluation of infection control and prevention policies and practices (14).

Considering the current high levels of HAI rates in NH settings, it is likely that activities, information and public policies regarding infection control and prevention in NHs can be improved (15). Therefore, the aim of this study was to survey state DOH websites with regard to information, resources and quality indicators regarding HAI prevention in NH. Previous researchers have evaluated whether availability of Medicare's Nursing Home Compare website is associated with infection rates (16, 17).

However, our study includes a much broader array of quality indicators, directed at different audiences. Furthermore, although previous researchers have reviewed internet-based NH quality indicators (10, 18) and infection control and prevention resources that may affect clinical practices in NHs (19), to our knowledge, no investigator has described the diversity of state DOH activities and information focused on reducing HAI in NH across states (10, 18, 19). Such information could be useful to infection preventionists, especially those working as infection prevention coordinators in NH, to effectively use these resources. Furthermore, this information may be useful to state DOH HAI advisory board members and DOH staff in state HAI programs, both of which include infection preventionists.

Methods

This original investigation was conducted as part of Prevention of Nosocomial Infections and Cost Effectiveness in Nursing Homes (PNICE-NH) study (National Institutes of Nursing Research, NINR, R01NR013687), which was previously approved by The Institutional Review Board of Columbia University Medical Center.

Tool Development

We created a standardized data collection tool, which was informed by review of 20 state DOH websites, to determine the types and breadth of infection control and prevention activities directed at NH. To assure content validity, the tool was reviewed by experts in the field, each with extensive publications regarding geriatric care and/or infection control. The initial tool was refined through an iterative piloting process by two independent raters. Pilot testing was conducted with 5 state DOH websites. The final 17-item tool had fair to excellent reliability (Cohen's Kappa coefficients of 0.45-0.73).

A data collection protocol was created to ensure consistent abstraction of data from state DOH websites and interpretation of the tool items by data abstractors. The protocol contained operational definitions of state activities, information and policies related to HAI focus. The protocol also provided an outline for navigating state DOH websites and documenting abstracted information.

Tool Items

Items were organized by target audience of activities that focus on NH quality: consumers, providers, and surveyors. The tool also included a section regarding state policies specific to HAI in NH.

Consumer information included checklists and guidance materials used to choose a NH, a venue for complaints against facilities (ombudsman), and inspection data, i.e., inspection reports, report cards and links to Medicare's Nursing Home Compare. We noted the format in which NH quality indicators were presented, i.e., on a report card or in another format.

Provider-directed information included data or descriptions of collaboratives or advisory boards focused on HAI reduction in NH and training or guidance materials for appropriate infection control and prevention practices in this setting. Surveyor-focused information contained training materials to complete NH inspections. Public policy items identified HAI reporting laws in NH and determined whether the state HAI prevention plan addressed long-term care.

Data Collection

Data were systematically abstracted from 50 state and District of Columbia DOH websites. If a first reviewer found it difficult to identify activities and information related to state DOH focus on NH, for example, when links of interest had low visibility within the DOH website, when these links were organized with unrelated information or finding them required multiple keyword searches within the website, a second reviewer also independently abstracted data from the website (n = 11). In cases of disagreement, website content was reviewed and discussed to reach consensus. Establishing whether states required HAI reporting in NH and distinguishing between state mandatory reporting and notifiable conditions was particularly difficult. For example, state HAI reporting forms for providers available on the DOH website may list the conditions of interest and request case information without explicitly stating the type of reporting for which the form should be used. Hence, state HAI coordinators in 23 states were contacted by phone and email to provide clarification. All data were collected and compiled between November 2012 and January 2013.

Data Analysis

Descriptive statistics and Cohen's Kappa coefficients were computed using SAS 9.2 (20).

Results

Consumer-Directed Information

Table 1 provides an overview of the information on state DOH websites to help potential residents and their caregivers assess NH quality and choose a NH. For consumers choosing a NH, 74.5% of states

provided at least one link to a NH checklist. Of the states with checklists, 39% had created them and 55.3% used the list provided by Medicare (http://www.medicare.gov/Pubs/pdf/02174.pdf, data not shown). Four other state DOH provided a checklist from either AARP (http://assets.aarp.org/www.aarp.org_/promotions/text/life/NursingHomeChecklist.pdf), or Aging Parents and Eldercare (http://www.aging-parents-and-elder-care.com/Pages/Checklists/Nursing_Home.html). The source of one NH checklist could not be determined. All states and the District of Columbia provided a link to an ombudsman and 84.3% provided guidance materials for choosing a NH.

With the exception of one state, all states provided at least one link to Medicare's Nursing Home Compare website (http://www.medicare.gov/nursinghomecompare). Most states also provided CMS inspection report data (70.6%). In some cases, websites included facility characteristics that indicated quality that were not captured through CMS inspections (31.4%), such as patient, family or employee satisfaction rates. Approximately one-third of the states compiled facility-level information in report cards.

Table 2 presents the types of quality indicators found in the report cards or in other formats. State DOH websites that did not offer report cards presented a variety of information indicating nursing home quality (n = 25). The most common type of information not in a report card format available among state DOH websites was deficiency citations identified during CMS inspections (96%). Complaints made against a facility were usually identified (84%) often in the context of whether they were substantiated through facility inspection. The majority of states also indicated whether citations required penalty enforcement due to their scope or severity, i.e., a violation (60.8%). However, few states offered information regarding indicators of excellent quality, as opposed to indicators of poor quality, such as best practice awards. While state DOH also offered quality indicators beyond citations, such as complaints, violations and follow-up reports on these items, it was generally more common to offer these data in report card formats.

Types of information provided on report cards also varied. The most common quality indicators appearing on report cards were citations/deficiencies (86.7%), violations (80%), and complaints (73.3%). Quality indicators only appearing on report cards included administration quality/satisfaction rating, resident satisfaction, and quality rating compared to other local NH.

Provider and Surveyor-Directed Information

Table 3 provides an overview of the information regarding infection control and prevention provided to NH providers and surveyors. Almost one-third (n = 15) of state DOH websites mentioned an advisory council, working group or collaborative that addressed HAI incidence in NH. The majority of states (n = 44, 86.3%) had infection control and prevention training or guidance for NH personnel, often through links to CDC materials for long-term care facilities or on the state DOH website directly. Roughly half of state DOH (52.9%) offered training or guidance materials for conducting NH inspections.

State HAI Prevention Plans

State HAI prevention plans included similar language adapted from a template, but plans varied as to whether NH were included in the outlined activities. State HAI prevention plans in 82.4% of states indicated the intention to establish a statewide advisory council to lead HAI rate reduction efforts in "long-term care facilities" or "nursing homes". Only six states (11.8%) indicated the intention to establish standards and evaluate complaints regarding infection control and prevention practices in this setting through collaboration with professional licensing organizations (Indiana, Massachusetts, Michigan, New Mexico, Tennessee and Texas). The majority of state HAI plans (60.8%) indicated intention to establish infection prevention collaboratives in non-hospital settings, specifically NH, to reduce HAI. No updates to any of the state plans were apparent to reviewers since the initial January 1st, 2010 deadline when states were required to submit HAI prevention plans to HHS in order to receive preventive health services block grant funds from the CDC (9).

HAI Reporting

Five states had HAI reporting in NH; among those states, infections that were reported varied (Table 4). Only two states (Pennsylvania and Oregon) had mandatory HAI reporting laws applicable to NH. Pennsylvania was the first state to establish HAI reporting in NH, beginning in 2008, and appeared to have the most extensive requirements. Additionally, contacting state DOH representatives of HAI control and prevention programs revealed that three states (Georgia, Vermont and Iowa) had recently initiated voluntary reporting of HAIs in NH.

Discussion

This study demonstrates high variability in state activities and policies focused on NH and reducing HAI incidence in NH. The vast majority of states provided consumer-directed information for

assessing NH quality intended to help consumers make informed decisions when considering residence in one of these facilities. Overall, Florida, Maryland, Massachusetts, Minnesota, Ohio, and Rhode Island provided the greatest number of consumer-directed activities and venues of information. These states also provided the most quality indicators of individual NH facilities, though the types of indicators were different between the states. Our findings are consistent with previous literature describing variation across states in the availability, content, data aggregation level and quality indicators provided on NH report cards (10). While many states provided some information concerning provider and surveyor activities and resources indicative of state focus on HAI, websites from Delaware, Kentucky, North Carolina, Michigan, Oregon, West Virginia and Wisconsin included the largest amount of information or activities provided by state DOH in this category. Pennsylvania not only included NH in multiple aspects of the state HAI prevention plan, but also had extensive HAI mandatory reporting requirements for NH. Pennsylvania's public policy focus on HAI in NH was followed closely by Georgia, Indiana, Iowa, Massachusetts, Michigan, New Mexico, Oregon, Tennessee, and Texas. Because no states were clearly outpacing others along all indicators, our data may represent different approaches to HAI reduction in NH across states rather than absolute presence or absence of state focus on HAI in NHs.

Our findings that information and policies vary between states are not surprising considering that federal focus to reduce HAI, driven by the Department of Health and Human Services, has delegated planning and implementation to the state DOH. Although states hoping to receive CDC preventative services block grant funds had to devise their own HAI prevention plan, there was no direct funding provided for HAI prevention activities. States had to find and allocate their own resources to pursue the plan. The American Reinvestment and Recovery Act (ARRA) ultimately increased funding for, and oversight of, HAI reduction activities at the state level, but provided limited guidance towards achieving HAI reduction in NH (9). Therefore, it is not surprising that each state DOH devised divergent approaches to HAI prevention in NH as demonstrated in this work. Our data highlight the variation in state DOH activities, information and policies which should be considered in future work comparing HAI rates in NH across states.

Using websites to collect these data presented challenges relevant for future studies that might also use online data abstraction, especially regarding state DOH activities, information and public policy.

As most state DOH websites were unexpectedly difficult to navigate and understand, it was often challenging to find and interpret NH HAI-related information. As noted in the Methods section, a second reviewer was needed to confirm the absence of specific data of interest and/or double-check data abstraction accuracy for approximately 10 states. Additionally, we communicated directly with state DOH HAI prevention program representatives from 23 states. This lack of clarity was reflected in the somewhat lower Kappa statistics for our data collection tool; even with highly skilled reviewers with advanced degrees in the health professions, agreement could not always be reached. It is likely that many consumers would also have difficulty navigating the websites.

Considering that most consumers need to choose a NH imminently (11), the current difficulty using many state DOH websites to access information about NH indicates a distinct need for improvement. Furthermore, the absence of information regarding state DOH activities does not mean it was not available. Although it is possible that relevant information on state DOH websites was missed by both data abstractors, information may be communicated through other means to the relevant stakeholders and was therefore not on the website. However, purposeful public availability of this information on the DOH website presumably indicates some defined focus on NH across the state.

A strength of this study is that methodology included contacting state HAI coordinators to abstract data regarding HAI mandatory reporting. We contacted 23 state HAI coordinators where laws were unclear and/or HAI reporting was indistinguishable from notifiable conditions. Based on these responses, we determined that only 2 states had mandatory reporting and an additional 3 states had voluntary reporting. Using a review of public health laws, the Association for Professionals in Infection Control and Epidemiology, Inc. (APIC) found that reporting of HAI in NH is required by 4 states (21). States' enforcement of HAI-related policies may explain the difference between results of this study and of APIC's previous work. Given the timing and methodology of our study, we are confident that our data represent the most accurate information about current reporting of HAI in NH.

Of note, this research did not address lists of notifiable conditions in each state, only mandatory and voluntary HAI reporting laws. In completing the data collection tool, reviewers noted that these lists varied between states and included some HAI. Identifying HAI reporting through notifiable conditions lists is a valuable area for future research.

The data described here provide characterization of state focus on NH quality and HAI reduction, allowing for the comparison of health policy, information and activities between states. Understanding ways in which state DOH attempt to reduce HAI in NH can inform work of infection preventionists, as well as health policy researchers, geriatricians and other NH healthcare workers. Continuation of this work should include study of how the target audiences of state DOH information and activities (i.e., consumers, providers and surveyors) use them, if at all, to determine the impact of state DOH efforts to improve NH quality and reduce HAI in NH.

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Table 1. Consumer resources.

DOH Consumer Resource N = 51	**n (%)**	**States**
Checklist for choosing a NH	38 (74.5)	AK, AL, AR, AZ, CA, CO, CT, DC, DE, FL, GA, HI, ID, IL, IN, KS, LA, MA, MD, MI, MN, MO, MS, NE, NH, NV, NY, OR, PA, RI, SD, TX, UT, VA, VT, WI, WV, WY
Guidance material for choosing a NH	43 (84.3)	AK, AL, AR, AZ, CO, CT, DC, DE, FL, IA, ID, IL, IN, KS, KY, LA, MA, MD, MI, MN, MO, MS, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OR, PA, RI, SD, TX, UT, VA, VT, WA, WI, WV, WY
Link to ombudsman	51 (100.0)	All
Link to Medicare's NH compare	50 (98.0)	All except SD
Inspection report data	36 (70.6)	AL, AZ, CA, CO, DC, DE, FL, IA, ID, IL, IN, KS, KY, LA, MA, MD, MI, MN, MO, MS, NC, ND, NJ, NM, NV, NY, OH, OK, PA, RI, SD, TN, TX, VT, WI, WY
Non-CMS inspection report information	16 (31.4)	AZ, CA, CO, GA, IA, KY, MD, MN, NC, NJ, OH, OR, RI, TN, VA, WI
Report card	15 (29.4)	CA, FL, IA, IN, LA, MA, MD, MI, MN, NJ, NY, OH, RI, TX, WI

Note: NH, Nursing home; DOH, department of health; CMS, Centers for Medicare and Medicaid Services.

Table 2. Presentation of nursing home quality information.

Quality Indicator	Indicator Present N = 51 n (%)	Report Card Format* n = 15 n (%)	Other Format n = 25 n (%)
Citations/deficiencies	37 (73)	13 (87)	24 (96)
Complaints	32 (63)	11 (73)	21 (84)
Violations	31 (61)	12 (80)	19 (76)
Facility follow-up reports	23 (45)	7 (47)	16 (64)
Performance ranking or measure	8 (16)	7 (47)	1 (4)
Quality of care	8 (16)	7 (47)	1 (4)
Staffing	7 (14)	5 (33)	2 (8)
Administration quality/satisfaction rating	6 (12)	6 (40)	0 (0)
Best practice awards/distinction	6 (12)	2 (13)	4 (16)
Resident satisfaction	5 (10)	5 (33)	0 (0)
Quality of life	5 (10)	4 (27)	1 (4)
Relative rating in area	4 (8)	4 (27)	0 (0)
Health indications	4 (8)	2 (13)	2 (8)
Finances	2 (4)	1 (7)	1 (4)

Note: NH, Nursing home; DOH, department of health.
*Of the 51 states and District of Columbia, 40 states provided NH quality indicator information. Of these 40 states, 15 states provided a report card containing the quality indicators, and 25 states provided the quality indicators in a format that was not a report card.

Table 3. Provider and surveyor-directed information.

DOH Resource* N = 51	Total State DOH Offering Resource n (%)	States With Resource
Provider group addressing HAI	15 (29.4)	AZ, CT, DE, FL, GA, IL, KY, MI, NC, OR, PA, VA, WI, WV, WY
Provider HAI prevention training or guidance	44 (86.3)	AK, AL, AR, AZ, CA, CO, CT, DE, FL, GA, HI, IA, ID, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MT, NC, ND, NE, NM, NV, NY, OH, OR, PA, RI, SC, SD, TX, UT, VA, VT, WA, WI, WV
Surveyor training or guidance for inspections	27 (52.9)	CO, DC, DE, IA, ID, IN, KS, KY, LA, ME, MI, MN, MT, NC, NE, NM, OH, OK, OR, RI, SC, TN, UT, WA, WI, WV, WY

Note: HAI, Healthcare-associated infection; DOH, department of health.
*States and District of Columbia may offer more than one of these resources (i.e., these categories are not mutually exclusive).

Table 4. States with HAI reporting in NH.

HAI Reporting	State	HAI	Implementation Date
Mandatory			
	PA	*C. difficile*, symptomatic urinary tract infection, symptomatic catheter-associated urinary tract infection, central line-associated blood stream infection, primary blood stream infection, ventilator-associated pneumonia, lower respiratory infection, influenza/influenza-like illness bronchitis/tracheobronchitis, surgical site infection, cellulitis, burns, vascular and diabetic ulcer, device-associated soft-tissue/wound infection, gastrointestinal infection (viral, bacterial, other), peritonitis/deep abscess, meningitis, decubitus ulcer infection, viral hepatitis, osteomyelitis	2008
	OR	Urinary tract infection	2010
Voluntary			
	IA	*C. difficile*	2012
	GA	Catheter associated urinary tract infection	2013
	VT	Multidrug resistant organism, *C. difficile*	2013

Note: HAI, Healthcare-associated infection.

Appendix A: State DOH Websites

State	Website	Access Date* *(mm/dd/yy)*
Alabama	http://www.adph.org/	01/09/13
Alaska	http://dhss.alaska.gov/Pages/default.aspx	01/28/13
Arizona	http://www.azdhs.gov/	01/07/13
Arkansas	http://www.healthy.arkansas.gov/Pages/default.aspx	01/28/13
California	http://www.dhcs.ca.gov/Pages/default.aspx	01/08/13
Colorado	http://www.colorado.gov/cs/Satellite/CDPHE-Main/CBON/1251583470000	01/09/13
Connecticut	http://www.ct.gov/dph/site/default.asp	01/04/13
Delaware	http://dhss.delaware.gov/dhss/	01/03/13
District of Colombia	http://doh.dc.gov/	01/10/13
Florida	http://www.doh.state.fl.us/	01/04/13
Georgia	http://health.state.ga.us/	01/08/13
Hawaii	http://hawaii.gov/health/	01/02/13
Idaho	http://www.healthandwelfare.idaho.gov/	01/07/13
Illinois	http://www.idph.state.il.us/	01/10/13
Indiana	http://www.state.in.us/isdh/	01/16/13
Iowa	http://www.idph.state.ia.us/	01/17/13
Kansas	http://www.kdheks.gov/	12/27/12
Kentucky	http://chfs.ky.gov/dph/	01/14/13
Louisiana	http://www.dhh.louisiana.gov/	01/03/13
Maine	http://www.maine.gov/dhhs/	01/03/13
Maryland	http://dhmh.maryland.gov/SitePages/Home.aspx	01/07/13
Massachusetts	http://www.mass.gov/eohhs/gov/departments/dph/	01/05/13
Michigan	http://www.michigan.gov/mdch	01/07/13
Minnesota	http://www.dhs.state.mn.us/main/idcplg?IdcService=GET_DYNAMIC_CONVERSION&RevisionSelectionMethod=LatestReleased&dDocName=health_care	01/03/13
Mississippi	http://www.msdh.state.ms.us/	11/24/12
Missouri	http://health.mo.gov/index.php	01/15/13
Montana	http://www.dphhs.mt.gov/	01/03/13
Nebraska	http://dhhs.ne.gov/Pages/default.aspx	01/15/13
Nevada	http://dhhs.nv.gov/	12/06/13
New Hampshire	http://www.dhhs.nh.gov/	01/16/13
New Jersey	http://nj.gov/health/	01/02/13
New Mexico	http://www.health.state.nm.us/	01/08/13
New York	http://www.health.ny.gov/	01/13/13
North Carolina	http://www.ncdhhs.gov/	01/08/13
North Dakota	http://www.ndhealth.gov/	01/15/13
Ohio	http://www.odh.ohio.gov/	11/24/12
Oklahoma	http://www.ok.gov/health/	01/10/13
Oregon	http://www.oregon.gov/DHS/Pages/index.aspx	12/26/12
Pennsylvania	http://www.portal.health.state.pa.us/portal/server.pt/community/department_of_health_home/17457	01/16/13
Rhode Island	http://www.health.ri.gov/	01/10/13
South Carolina	http://www.scdhec.gov/	01/14/13
South Dakota	http://doh.sd.gov/	01/10/13
Tennessee	http://health.state.tn.us/	01/17/13

Texas	http://www.dshs.state.tx.us/	01/10/13
Utah	http://health.utah.gov/	01/03/13
Vermont	http://healthvermont.gov/	01/07/13
Virginia	http://www.vdh.state.va.us/	01/17/13
Washington	http://www.doh.wa.gov/	01/17/13
West Virginia	http://www.wvdhhr.org/	01/08/13
Wisconsin	http://www.dhs.wisconsin.gov/	01/08/13
Wyoming	http://www.health.wyo.gov/default.aspx	01/08/13

*Last date of internet-based data abstraction.

Additional Appendix B. Evaluation of Conceptual Frameworks Applicable to the Study of Isolation Precautions Effectiveness

The following supplemental appendix is a study lead by the author. It describes a systematic search and evaluation of conceptual frameworks that are applicable to determine the effectiveness isolation precautions. Moreover, the process described here may be useful to chose a conceptual framework for other areas of study.

Note. The contents of this supplemental appendix are a manuscript accepted for publication by the *Journal of Advanced Nursing*.

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ABSTRACT

Aims: A discussion of conceptual frameworks applicable to the study of isolation precautions effectiveness according to Fawcett and DeSanto-Madeya's (2013) evaluation technique and their relative merits and drawbacks for this purpose

Background: Isolation precautions are recommended to control infectious diseases with high morbidity and mortality, but effectiveness is not established due to numerous methodological challenges. These challenges, such as identifying empirical indicators and refining operational definitions, could be alleviated though use of an appropriate conceptual framework.

Design: Discussion paper

Data Sources: In mid-April 2014, the primary author searched five electronic, scientific literature databases for conceptual frameworks applicable to study isolation precautions, without limiting searches by publication date.

Implications for Nursing: By reviewing promising conceptual frameworks to support isolation precautions effectiveness research, this paper exemplifies the process to choose an appropriate conceptual framework for empirical research. Hence, researchers may build on these analyses to improve study design of empirical research in multiple disciplines, which may lead to improved research and practice.

Conclusion: Three frameworks were reviewed: the epidemiologic triad of disease, Donabedian's healthcare quality framework and the Quality Health Outcomes model. Each has been used in nursing research to evaluate health outcomes and contains concepts relevant to nursing domains. Which framework can be most useful likely depends on whether the study question necessitates testing multiple interventions, concerns pathogen-specific characteristics and yields cross-sectional or longitudinal data. The Quality Health Outcomes model may be slightly preferred as it assumes reciprocal relationships, multi-level analysis and is sensitive to cultural inputs.

SUMMARY STATEMENT

Why is this research or review needed?

- Evidence regarding the effectiveness of isolation precautions remains weak due to numerous methodological challenges.
- Although infection control is inherently multidisciplinary, nursing practice is an important component; hence, effectiveness research in this field should incorporate nursing perspectives.
- Study design and therefore strength of research findings may be improved through use of a conceptual framework congruent with nursing theory.

What are the key findings?

- Three conceptual frameworks were identified that may be most applicable to guide study design for isolation precautions effectiveness research.
- Which framework can be most useful likely depends on whether the study question necessitates testing multiple interventions, concerns pathogen-specific characteristics and yields cross-sectional or longitudinal data.
- The Quality Health Outcomes framework has the advantages of assuming reciprocal relationships and multi-level analysis and incorporating sensitivity to cultural differences.

How should the findings be used to influence policy/practice/research/education?

- Future research regarding isolation precautions effectiveness should use a conceptual framework such as one of the three identified in this paper.
- This paper outlines a critical thinking process to decide between conceptual frameworks for study design, policymaking or intervention implementation.
- Those reviewing and synthesizing evidence regarding isolation precautions should consider the Quality Health Outcomes model to encourage culturally sensitive data abstraction and quality assessment.

KEYWORDS

Theoretical models, conceptual analysis, nursing, patient isolation, cross-contamination, healthcare-associated infection, barrier precautions, contact precautions, infection prevention, infection control

INTRODUCTION

Isolating those with communicable pathogen(s) has been a key means to control disease since the black plague in the 14th century (Landelle et al. 2013). Today, isolation precautions are still a preferred method in many healthcare systems to control infectious diseases with high morbidity and mortality, such as Methicillin-resistant Staphylococcus aureus (Smith et al. 2008, Siegel et al. 2007). However, high resource requirements (Kirkland 2009), associated adverse events (Morgan et al. 2009) and evidence-based medicine prioritization (Swanson et al. 2010) have sparked debate as to whether existing data regarding isolation precautions are adequate to guide effective practice (Gasink and Brennan 2009). This debate intensified following transmission of Ebola virus to healthcare workers in the U.S. despite use of isolation precautions (Santora 2014). It is important to generate new, consistent data regarding optimal infection control techniques to improve clinical practice (Centers for Disease Control and Prevention 2013).

However, it remains challenging to demonstrate isolation precautions are effective. Recent studies of isolation precautions effectiveness took place in many different countries including France (Gbaguidi-Haore et al. 2008), Great Britain (Cepeda et al. 2005), Hong Kong (Cheng et al. 2010), Israel (Cohen et al. 2011), Taiwan (Lin et al. 2011) and the United States (Bearman et al. 2010, Bearman et al. 2007). Similar studies were rarely repeated in the same country. As wide variation exists in clinical practice guidelines regarding isolation precautions, even among those from English-speaking countries (Aboelela et al. 2006), variation in the healthcare systems and isolation precautions processes threatens external validity of study results (Zastrow 2011). Therefore, it is difficult to combine and draw conclusions from this international body of literature.

Although substantial methodological barriers exist in this area, improvement is possible. Challenges that are difficult or impossible to address include establishing temporality between exposure and infection given new resistance and asymptomatic colonization periods (Gasink and Brennan 2009) and blinding intervention and outcomes (Aboelela et al. 2006). As isolation precautions are not recommended in all countries, randomized controlled trials of isolation precautions are uncommon. Because the most relevant study designs (quasi-experimental and observational studies) limit the researcher's ability to control for confounders (Siegel et al. 2007), addressing confounders and accounting for bias is critical. Future

studies may also improve on existing literature assessing compliance with all aspects of the intervention (Landelle et al. 2013) as well as fully describing the environment and outcome assessment methods . Careful study design to evaluate isolation precautions is essential, not only to produce rigorous results, but also to fully consider all the risks and benefits to patients, providers, facilities, allowing interpretation of findings by an international audience.

Background

Using a conceptual framework can be an effective tool to guide research of complex problems by helping to define concepts relevant to the phenomenon of interest and outline the relationships between these concepts (Fawcett and Desanto-Madeya 2013). Conceptual frameworks also can help to refine operational definitions and identify empirical indicators for these concepts. They aid derivation of theories, research questions and corresponding logical hypotheses to be tested in empirical research (Fawcett and Desanto-Madeya 2013). Given the difficulties of studying isolation precautions, appropriate conceptual frameworks may advance theory generation and improve evaluation through empirical research.

When designing a study, it is essential to ensure that the chosen conceptual framework and theory under investigation are logically aligned (Fawcett and Desanto-Madeya 2013). While infection control and prevention is inherently a multidisciplinary effort, nurses are a critical component given their frequent, direct patient contact, education and research roles. Therefore, effectiveness research should consider nursing roles, perspectives and theory to maximize applicability of research findings. Models from other disciplines which appear potentially applicable to nursing issues ‘should be critically analyzed and evaluated before it is introduced into nursing curricula, empirically tested or applied in nursing practice’ (Sullivan 1989).

The objective of this paper is to support study design by identifying, analyzing and evaluating conceptual frameworks to study the effectiveness of isolation precautions. This paper discusses the relative merits and drawbacks of each to frame empirical research on this topic and compares which conceptual frameworks are best-suited for various study designs used to evaluate isolation precautions effectiveness. Further, it outlines a critical thinking process regarding how to choose a conceptual framework, which may of useful beyond infection control research.

Data Sources

In mid-April 2014, C.C.C. performed a systematic search of electronic, scientific literature databases for peer-reviewed publications using or describing a conceptual framework applicable to examine the effectiveness of isolation precautions. Databases included PubMed, Ovid Medline, EBSCO Cumulative Index of Nursing and Allied Health Literature (CINAHL), Cochrane Central Register of Clinical Trials and Cochrane Database of Systematic Reviews. Keyword searches were supplemented by Medical Subject Headings (MeSH) terms in the search criteria, where applicable and related to the following concepts: Patient isolation (i.e., 'barrier precautions', 'contact isolation', 'contact precautions', 'isolation precautions', 'quarantine') and conceptual frameworks (i.e., 'theoretical model', 'conceptual model', 'organizing framework', 'theoretical framework'), in singular and plural forms. Search parameters included publication in English. Searches were not limited by publication date.

C.C.C. examined titles and abstracts of papers returned through database searches for potentially applicable conceptual frameworks. Additional publications were sourced through reference lists of papers returned in the database search. Conceptual frameworks previously known to the authors were also considered. C.C.C. then identified original literature that proposed these frameworks of interest as well as publications by the original author(s) that further elaborate on these frameworks.

Frameworks selected for analysis were included based on 1) applicability to the study of isolation precautions effectiveness and 2) the number of times the publications that originally proposed this conceptual framework has been cited on PubMed. Applicability and usefulness of the identified conceptual frameworks were evaluated following the analysis technique outlined by Fawcett and DeSanto-Madeya (Figure 1) (Fawcett and Desanto-Madeya 2013).

DISCUSSION

Searches of electronic databases yielded 128 publications, 25 of which were duplicates. Six conceptual frameworks were identified relevant to the study of isolation precautions (Table 1). Among the six frameworks, the epidemiologic triad of disease (though not always titled as such, as discussed below) was most frequently cited by other publications in PubMed (247 times), followed by Donabedian's healthcare quality framework (67 times) and Quality Health Outcomes framework (21 times). The other two frameworks were each cited less than four times. We described the three more frequently cited frameworks and evaluated their usefulness to study isolation precautions effectiveness (Table 2).

Epidemiologic Triad of Disease

Description

The epidemiologic triad of disease is also referred to in the literature as the 'epidemiologic triad of agent/host/environment' (Bernardo et al. 2002), 'host-agent-environment complex' (Smith 1986), 'agent-host-environment model' (Zastrow 2011), 'epidemiologic triangle' (Huerta and Leventhal 2002) and the 'traditional public health triangle' (Wilde 1997). As detailed in a textbook focused on 'health promotion and disease prevention' in medicine and dentistry (Leavell and Clark 1958), the motivation for development of this model was to frame infection prevention strategies (Clark 1954) and assemble facts in a body of knowledge regarding the natural history of disease (Leavell and Clark 1958). Although originally developed to describe infectious disease, the framework was also used in studies related to non-infectious disease, such as lead poisoning (Clark 1954) or nutrient deficiency (Leavell and Clark 1958).

The epidemiologic triad of disease identifies three components necessary to initiate and propagate illness (Leavell and Clark 1958), including a host (i.e., susceptible individual), an agent (i.e., a pathogen) and environment compatible with transmission of a disease-causing entity (Figure 2). As such, the environment, described as 'all things except man himself' (Leavell and Clark 1958), also includes biologic and socioeconomic factors in addition to the physical environment that 'may be preparing the way long before pathogenesis is initiated' (Clark 1954). In the original framework, Clark (1954) targeted interventions to intercept the causes contributing to disease process and proposed five 'levels of application of preventive measures' (Clark 1954). Variations of this model including a central 'vector' concept linking the other three (Huerta and Leventhal 2002) and presenting the framework as a tripod (or triangle) of the three concepts (Scholthof 2007) rather than a balance between agent and host with environment as the fulcrum (Leavell and Clark 1958).

Analysis

Because this framework is originally from the medical discipline, it purports no philosophical beliefs, values, goals or descriptions with regard to nursing practice. The authors' views regarding the general purpose of nursing interventions are not stated in descriptions of the framework, neither are relationships to the domains of nursing. The general method of knowledge development using this framework is deductive as Leavell and Clark (1958) believe that knowledge of the natural history of disease can 'fill in

the gaps' regarding what is known of the agent, host and environment in a particular situation (Leavell and Clark 1958), that is, using theory to deduce what empirical observations may occur (Reed 2012).

Regarding nursing metaparadigm domains of nursing, environment, health and person(s)/client/human beings (Peterson and Bredow 2013), the model could be interpreted as addressing client and the environment. Human beings are described as both a reservoir of disease and also a compilation of 'habits and customs' and that influence the interaction between agents of disease and the individual (Clark 1954). As mentioned above, environment is described as multi-factorial influences on the 'life and development of an organism', including biologic and socioeconomic as well as physical entities (Clark 1954). Because the authors wanted to outline a health promotion philosophy when developing this framework, health is implied in this model through the host's level of susceptibility. Nursing is not included, which might be interpreted as a significant weakness of this model for framing interventional research.

Evaluation

The origins of the model in medical epidemiology are not an inherent weakness for nursing or multidisciplinary studies as many conceptual frameworks of non-nursing origin have been successful to generate and test nursing theory (Fawcett and Desanto-Madeya 2013). This framework has been used in nursing research (Bernhardt and Langley 1999, Bernardo et al. 2002), including for infection control (Massanari 1989, Wilde 1997). In applications to the study of isolation precautions, this framework emphasizes a means to change the environmental component, breaking the links to both presence of an agent and contact with a susceptible host. The model was also specifically identified as a useful tool to study contact precautions (Zastrow 2011). Indeed, simplicity of the framework and breadth of concepts are strengths that enhance the model's applicability to diverse disciplines and topics.

However, the model is limited in comprehensiveness of content regarding nursing inputs and perspectives. The lack of a nursing or intervention-specific concept in the framework may not be a concern for describing the natural history of disease or even testing a single intervention's effects. However, to compare multiple interventions, the framework may require adaptation to capture effects of the interventions, especially if they affect the same concept (e.g., host) in different ways (e.g., education regarding isolation precautions procedures versus vaccination). Despite these weaknesses, researchers

have used this framework from nursing perspectives. For example, in the study of occupational nursing, Smith (1986) used the framework from a different worldview by assuming mutable agent, host and environment as well as dynamic relationships between these concepts (Smith 1986). Similarly, Reifsnider (1995) adapted the framework to show multiple inputs to each concept as well as reciprocal relationships between environment and host (Reifsnider 1995). Given that nurse scientists saw fit to adapt the model for use, the original framework may fail to capture the complexities of nursing interventions required to study isolation precautions.

Donabedian's Healthcare Quality Framework

Description

In 1966, Avedis Donabedian proposed that the quality of medical care can be evaluated through consideration of structure, process and outcomes of that care (Figure 3) (Donabedian 1966). Structure, the setting where medical care takes place and 'instrumentalities' that produce care processes, includes the 'adequacy of facilities and equipment' needed to provide care, provider qualifications, 'fiscal organization' as well as 'administrative and related processes that support and direct the provision of care (Donabedian 1966). Process, 'medical care' (Donabedian 1966), includes not only technical skills, but also whether medical evidence has been applied in decision-making, the 'appropriateness, completeness and redundancy' of information obtained regarding the client and whether the client values the care provided (Donabedian 1966). Outcomes of medical care, the 'recovery, restoration of function and of survival' of a client (Donabedian 1966), is described by Donabedian as product of structures and processes.

This framework applies to the study of isolation precautions as isolation precautions are represented in structure and process concepts. For example, structure encompasses the availability of a private room and processes include the use of gowns and gloves for contact with the patient and the patient's environment. Outcomes related to isolation may be infection or colonization with a specific pathogen, among others.

Analysis

With its medical field origin, Donabedian specifically focused on quality evaluation of physician-patient interaction, as this was 'familiar territory of care'(Donabedian 1966). Similarly to the epidemiologic

disease triad, Donabedian's model is not built on any philosophical beliefs and values specific to nursing nor does it inherently include any strategies for nursing knowledge development. It therefore does not have a unique focus in nursing. Donabedian's method of knowledge development using this model appears to be abductive system of reasoning, as it represents 'a conceptual leap form experience, beliefs and a pre-knowledge of patterns to arrive at an educated guess or theory about a phenomenon' (Reed 2012).

When Donabedian described this framework, he did not address domains of the nursing metaparadigm; however, when applying this framework to evaluate nursing or interdisciplinary care, the framework could incorporate all domains. *Human beings* are included both in structures (e.g., health care provider staffing) and in the influence of client characteristics on processes. Structure also describes the *environment* where healthcare is delivered. *Health* is measured by outcomes. Donabedian's model previously received criticism that structure and process concepts are ill-defined for *nursing* which may, at times, fit into both (Closs and Tierney 1993). However, for the sake of evaluating isolation precautions, both structure and process factors would certainly need to be considered in a well-designed study. Therefore nursing activities and attributes need not fit into a single concept in this model.

Evaluation

The Donabedian model is so well established in healthcare quality research that, despite its origins in medicine, one could argue that it is very well aligned and logically congruent with most nursing theory and knowledge developed in its wake. In nursing, it has been used to evaluate quality of hospice care (Richie 1987), elderly discharge planning (Closs and Tierney 1993), nurse practitioner services (Gardner et al. 2014) and obstetrical/labor and delivery patient perceptions (Hosek et al. 2014), among others. Research studies that use this framework demonstrate its social congruence in multiple geographic location and cultures (Chen et al. 2007, Closs and Tierney 1993), indicating the international relevance of its content. Considering that this framework has successfully guided nursing theory development and testing in this way, its empirically adequate use is a distinct strength (Fawcett and Desanto-Madeya 2013).

While the content of the framework is purposefully broad to be widely applicable, it may not be ideal to study isolation precautions as it lacks a clear component or role regarding the characteristics of pathogens (e.g., the 'agent' concept in the epidemiologic triad of disease). This reflects that the unique

focus of the model is not infection control. To use Donabedian's model in infection control studies, the structure component may best incorporate the concept of a dangerous agent present in the environment and perhaps the pathogen's virulence and pathogenicity.

Another limitation of this model is that 'the relation between structure and process is poorly understood' (Donabedian 1978). This lack of clear relational propositions between concepts may be a significant drawback for guiding studies on this topic. As such, nursing researchers have defined the relational propositions interactions more explicitly (Richie 1987) and also proposed new, adapted models (Chen et al. 2007, Shield et al. 2014, Mitchell et al. 1998).

Furthermore, the relationship between outcomes and other concepts in the Donabedian model also may not be ideal to study isolation precautions. For example, during a suspected influenza outbreak, confirmation of each additional case in a facility (outcomes) may change the process for isolation precautions for the next individual with a suspected case of influenza. The propensity to isolate and hence structures and processes of practice, will have changed as a result of what the Donabedian model identifies as outcomes. It is not clear how this reciprocal influence might be reflected in the Donabedian model.

Quality Health Outcomes Model

Description

Building on Donabedian's linear framework of healthcare quality improvement, the Quality Health Outcomes Model (Mitchell et al. 1998) includes four components: system, client, interventions and outcomes (Figure 4). System characteristics incorporate structure and process elements of the Donabedian model. Similar to processes in the Donabedian model, the interventions component represents clinical processes and related activities by which they are performed. Unlike Donabedian, Mitchell and colleagues specify client characteristics, which are indicators of health status, demographics and disease risk factors of individual patients, families and communities. Outcomes are health indicators such as morbidity, mortality and other variables dependent on the previously listed components (Mitchell et al. 1998). Relational propositions between concepts in the Quality Health Outcomes framework are dynamic and the relationship between interventions and outcomes is indirect and mediated by system and client components (Mitchell et al. 1998).

This framework applies to the study of isolation precautions effectiveness as it was developed to facilitate testing complex relationships between concepts with attention to nursing contributions (Mitchell et al. 1998). Interventions represent the processes of isolation precautions, while the system characteristics (e.g., nursing staffing ratios) and client characteristics (e.g., isolation adherence related to mental status) mediate the intervention's effects on the outcome (e.g., facility infection rate). The decision to isolate includes client and system characteristics, balancing the negative consequences of isolation on the individual with the benefits of reduced infection risk to a larger group of individuals. In this way, the content of this nursing conceptual model is appropriate to study isolation precautions.

Analysis

The origin of this model was the Outcomes Measures and Care Delivery Systems Invitational Conference (Mitchell and Lang 2004), which targeted defining categories of outcome indicators that can affect health policy. As such, the unique focus of this model is outcomes, especially nursing outcome research and management. The authors believe that a model with multiple feedback loops between the components and outcomes would be more sensitive to nursing inputs than the Donabedian model (Mitchell et al. 1998). The authors also incorporated multi-level analysis, as proposed by Holzemer and Reilly (1995) and clinical and functional outcomes introduced by Wilson and Clearly (1995) . Their motivation was to establish a model broad enough to guide database development, suggest key clinical intervention variables, provide a framework for research and influence health policy (Mitchell et al. 1998).

The authors appear to have used abductive reasoning (Reed 2012, Sullivan 1989) to develop this conceptual guide as it was derived from 'expert panel members' ongoing research, expert opinion and literatures of nursing and health services' (Mitchell and Lang 2004). However, the authors specifically support use of this model for inductive knowledge development ('the process of subjecting the theoretical ideas to empirical test' (Reed 2012)). Influences of specific philosophies are not stated. However, the authors' description of the model notes that the impacts of nursing inputs are mediated by individual client characteristics and contextual factors of the system where care is provided. This appears to take a postmodern approach (i.e., outcomes are dependent on context) (Reed 2012). Hence, both outcomes and mediators require sensitive measures to capture nursing value.

Mitchell and colleagues specifically incorporated all four nursing metaparadigm domains in this model (Mitchell and Lang 2004). The desire to incorporate broader outcomes than negative events (i.e., the 5-Ds: death, disease, disability, discomfort, dissatisfaction) (Mitchell and Lang 2004) reflects the domain of *health*. It may also be argued that *environment* is present in the system characteristics concept, intervention contains *nursing* and both client characteristics and outcomes can differentiate between illness and non-illness states. The *person(s)* domain might be interpreted as aspects of healthcare workers in system characteristics as well as influencing client characteristics.

Evaluation

Regarding the study of isolation precautions, the Quality Health Outcomes model is similar to Donabedian's framework in that it lacks an 'agent' concept as described by Leavell and Clark (1958). In this model, the system characteristics concept best incorporates presence of a disease agent. Another potential flaw in this model is that direct relationships between intervention and outcomes are not possible. As stated above, this framework purports that the relationship between intervention and outcomes is always mediated by system and client characteristics. Therefore, in a hypothetical study population that is homogenous with regard to system and client characteristics, the authors question whether relational propositions described by the model are meaningful. However, though individual studies regarding isolation precautions are often performed in a single unit or facility, it is unlikely that system and client characteristics can be sufficiently homogenized based on existing studies. In this way, the model appears to be appropriate for empirical research regarding isolation precautions with these mediators influencing the intervention-outcome relationship.

The strengths of this model are its intentionally broad concepts and numerous published examples of use in nursing research. This model has influenced theory relating health outcomes to nurse staffing (Shang et al. 2014), patient experience (Lundgren and Wahlberg 1999), system characterization (Dubois et al. 2012) and recognition of nursing excellence (Lake et al. 2012), among others. Contributions to the nursing discipline also include guiding several nursing report card initiatives (Mitchell and Lang 2004). The studies using this model indicate that the model has international relevance as they take place in multiple countries and represent different cultures (Brooks-Carthon et al. 2011, Shang et al. 2014). In summary, this model has been sufficiently validated through contributions to the nursing discipline.

Other key strengths of the Quality Health Outcomes model are the incorporation of system and client characteristics concepts and the assumption of multi-level analysis. First, the mediating concepts of system and client and indirect relationship between interventions and outcomes compels researchers to account for differences between populations and settings where studies of isolation precautions effectiveness are performed, for example, different resources available in another healthcare system and cultural influences of that country on psychological adverse events associated with isolation precautions. This is particularly important for repeating studies in diverse settings, interpreting findings from studies performed in other countries and synthesizing data collected in diverse geographic regions, which is particularly relevant to the highly international body of literature regarding isolation precautions effectiveness. Second, incorporation of Holzemer's multi-level analysis (Mitchell and Lang 2004) allows the model to address risk and benefits at both the individual and group levels. Including variables at multiple levels is integral to the study of isolation precautions as the isolation precaution benefits (e.g. reduced infection risk) are realized by a group of patients at the facility or unit level and the harms (e.g., depression) are specific to the individual in isolation. Therefore, the Quality Health Outcomes framework allows detailed reflection in study design of isolation precautions and considerations for cross-cultural sensitivities.

Implications for Nursing

Our review of scientific literature revealed that comparative evaluations of conceptual frameworks for their applicability to a given topic are rarely published, although researchers often evaluate and compare conceptual frameworks when designing research studies. This paper outlines thought processes to compare usefulness of conceptual frameworks. Therefore, this paper may be of use to researchers designing new studies and administrators and clinicians evaluating results of these studies in multiple fields beyond infection control practices.

Analysis and comparison of frameworks, as described in this paper, may be helpful to assist multidisciplinary projects and/or international collaborations in infection control as well as other fields. Multidisciplinary research necessitates conceptual translation, establishing uniform language and 'common or at least correlated approach to individual questions' (Kessel et al. 2008). Collaboration across cultures and healthcare systems also requires mutual conceptual understanding for success. For

example, combating the on-going Ebola epidemic requires a coordinated, global effort to maximize effectiveness of isolation precautions and other infection control practices with attention to local health beliefs, resources and disease strains. Evaluating and using a conceptual framework may be ideal to level expectations among stakeholders before beginning a study or intervention.

Regarding isolation precautions, use of a conceptual framework may improve empirical research design, leading to improved clinical practice. In previous studies, it is unclear whether authors did not address confounders or biases because it was impractical or whether these issues were not considered. However, application of one of these conceptual frameworks may have prompted authors to compare 'client characteristics' in the Quality Health Outcomes Framework (or 'host' in the epidemiologic triad) of the pre and post-intervention groups. For example, some previous studies did not report the proportion of the respective sample with immunocompromised status or indwelling devices (Bearman et al. 2010, Bearman et al. 2007, Cheng et al. 2010, Cohen et al. 2011), which are known risk factors for infection (Siegel et al. 2006). Further, operationalizing the process concept in Donabedian's framework (or 'intervention' in Mitchell's) may have prompted Gbaguidi-Haore et al. (2008) to report compliance, Cohen et al. (2011) to track compliance consistently across different phases of the study or Cepeda et al. (2005) and Cheng et al (2010) to record compliance for all components of the intervention. Detailing structure and processes (or 'environment' or 'system characteristics') would be helpful to understand equipment access, regular provider training and case communication, especially for studies conducted in different healthcare systems. Understanding the representativeness of the sample, level of intervention compliance and system characteristics would help clinicians to determine whether to apply these interventions in clinical practice.

All three conceptual frameworks reviewed in this paper could be used to guide study of isolation precautions, though none are ideal. While the epidemiologic triad of disease does not contain a clear concept for interventions but is sensitive to pathogenicity and virulence of specific infectious agents, the reverse is true of Donabedian's framework and the Quality Health Outcomes model. As isolation precautions are initiated in response to infection, lack of a pathway by which outcomes influence structure and process may be problematic. In this way, the Donabedian model would not help to address temporality between exposure and outcome, which is a significant challenge in infection control

intervention studies (Gasink and Brennan 2009). In contrast, Mitchell et al.'s (1998) recognition of need for multi-level analyses may help researchers to distinguish between individual-level outcomes that trigger isolation precautions and facility-level variables that follow isolation precautions use. Furthermore, The Quality Health Outcomes model also has a strength that differentiates it from Donabedian's framework and the epidemiologic triad of disease: incorporation of system and client characteristics concepts. Hence, the Quality Health Outcomes model may be slightly preferred for nursing studies regarding isolation precautions, depending on outcome(s) of interest and study design.

The strengths and weakness of the three conceptual frameworks indicate they may be better-suited to specific study designs used to evaluate isolation precautions. The epidemiologic triad of disease may be most useful for observational studies, especially cohort studies (i.e., exposure has already occurred (LoBiondo-Wood and Haber 2006)) where there is no need to observe the effects of an intervention, but perhaps a need to capture biological characteristics of the agent (e.g., presence of specific strains or pathogenicity). An example of such a study is Tschudin-Sutter et al., (2010) which assessed risk of developing extended-spectrum Beta-Lactamase-Producing Enterobacteriaceae among roommates of infected individuals (i.e., exposure prior to being moved into isolation precautions) (Tschudin-Sutter et al. 2012). Donabedian and Mitchell et al.'s frameworks are more efficient for interventional studies. The dynamic nature of the Quality Health Outcome framework would be well-suited to both mathematical model-based studies where all factors related to isolation precautions are simultaneously influencing others (e.g., cross-sectional analysis) (Chow et al. 2011), as well as capturing dynamic responses over time. While neither the Donabedian or Mitchell model has a direct path between outcomes and structure/process or intervention, respectively, Mitchell's framework contains an indirect pathway by which outcomes can influence interventions. Therefore, longitudinal studies may not benefit as much from the Donabedian model as from Mitchell's framework. However, pretest-posttest studies, as are often used to study isolation precautions (Aboelela et al. 2006), would not be affected by this drawback.

Limitations

Selecting seminal frameworks by the number of papers citing the original publication underestimated the importance of the oldest and newest frameworks. Publications influenced by a framework point to its associated theory generation, legitimacy and contributions to nursing knowledge (Fawcett and Desanto-

Madeya 2013). However, the most used framework is not necessarily the most useful. Further, studies using a framework may not always cite or indicate it in the corresponding publication. This is especially true of the epidemiologic triad of disease, which is not always named as such, despite description of ‘host’, ‘agent’ and ‘environment’ concepts in relation to disease control in many papers (Stirling 2004). As such, it is impossible to know all the ways these frameworks have be used in research and practice to date.

CONCLUSIONS

Going forward, the authors recommend that researchers carefully consider study design elements needed to determine the effectiveness of isolation precautions using one of the three conceptual frameworks discussed above. Future systematic reviews and meta-analyses should frame data abstraction and quality analysis through the Quality Health Outcomes framework as it incorporates elements that can be sensitive to cultural differences. Cross-cultural sensitivities will be important to interpret outcomes of studies conducted in many different countries, especially outcomes such as psychological adverse events of isolation precautions. Administrators, clinicians and researchers may draw from the critical thinking process outlined here when deciding between conceptual frameworks for study design, policymaking or intervention implementation. Hence, this paper has the potential to facilitate future research, international collaboration and multidisciplinary interaction in infection control and other fields.

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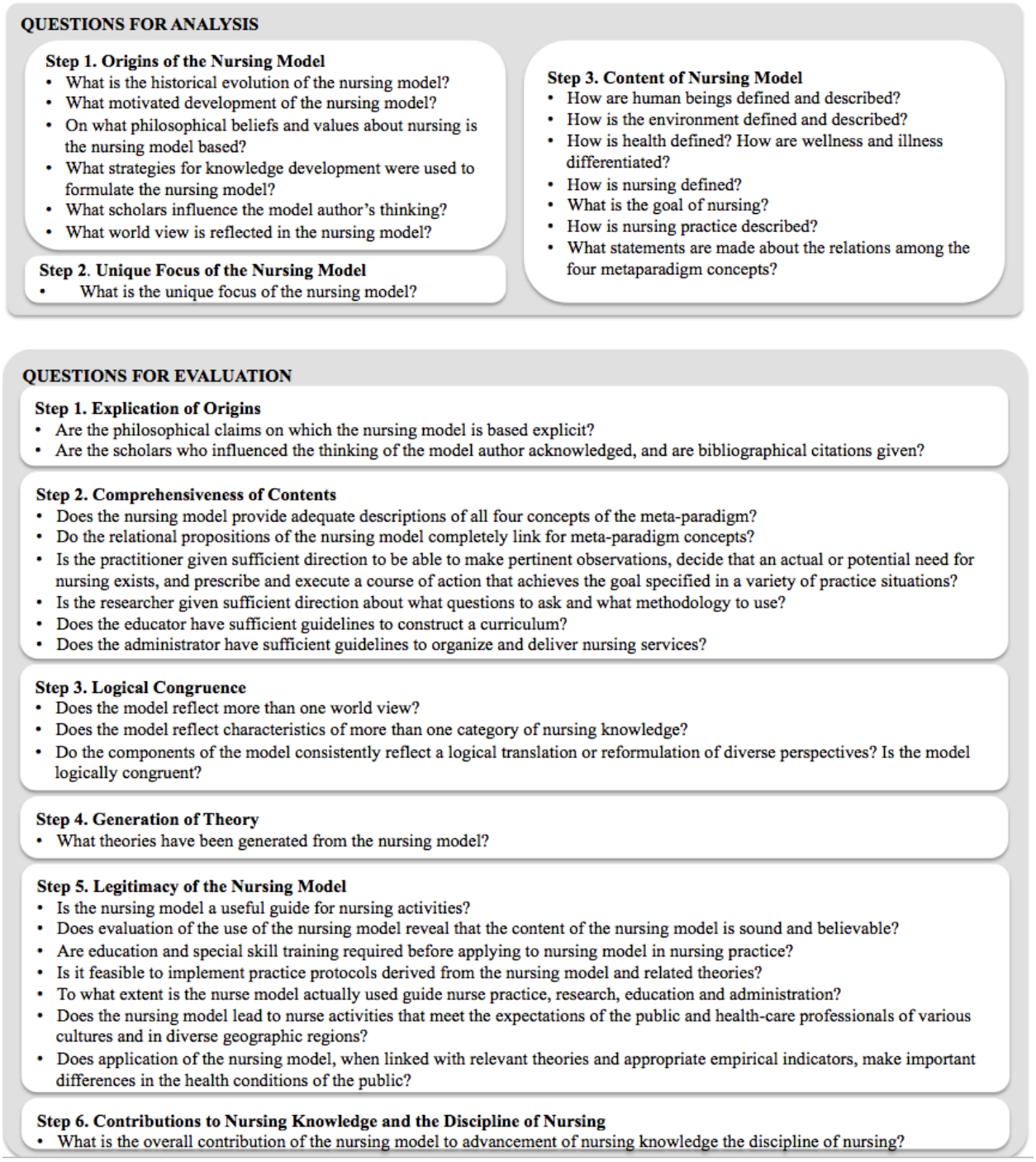

Figure 1. Framework for Analysis and Evaluation of Nursing Models (Adapted from Fawcett and Desanto-Madeya, 2013).

Table 1
Identified conceptual frameworks applicable to the study of isolation precautions, presented in chronological order of publication

Framework Name	Source	Description	Constructs Included	PubMed Citations
Epidemiologic triad of disease	Clark 1954	Describes the three categories of factors and their interrelationships that influence epidemics	• Agent • Host • Environment*	247**
Donabedian's healthcare quality framework	Donabedian 1966	Identifies three factors by which to assess the quality of health care delivery and the linear flow of influence between them	• Structure* • Process* • Outcome	67
Conceptual model of an infection surveillance and control program (ISCP)	Haley et al. 1981	Relates nosocomial infection (a patient characteristic) to all activities performed by an ISCP for the purpose of evaluating those activities' impact on the patient characteristics	• Approval by hospital authorities • Sources of program direction • Overall structure and function • Direct action* • Training • Influence of ISCP staff • Potential obstacles • Patient care staff's characteristics* • Patient characteristics*	1
Quality health outcomes framework	Mitchell et al. 1998	Building on Donabedian, introduces dynamic interrelationships between concepts and an indirect path between intervention and outcomes influenced by the system and client(s)	• System • Client • Intervention* • Outcome	21***
Predisposing, reinforcing and enabling factors in education and health diagnosis and evaluation model (PRECEDE)	Mody et al. 2011	Describes the process to implement interventions in high risk groups by health care workers, model proposed specifically in relation to prevention of HAI	• Predisposing aspects • Enabling factors • Reinforcing factors • Evaluate outcomes	3

HAI prevention system framework	Kahn et al. 2014	Specifies system-based components for HAI prevention and mitigation	• Infrastructure development* • HAI data and monitoring • Knowledge development* • Adoption of HAI prevention practices*	0

**Represents concept(s) in which isolation precautions are incorporated*
***Includes papers containing Agent-Host-Environment as in Clark (1954), though not cited and/or titled differently*
****Incorporates Mitchell and Lang (2004) and cited articles*
HAI = Healthcare associated infections; ISCP = Infection surveillance and control program.

Table 2 Evaluation of three most-cited frameworks applicable to the study of isolation precaution effectiveness			
Evaluation Criteria	**Clark (1954)**	**Donabedian (1966)**	**Mitchell (1998)**
Explication of Origins	**Yes.** Desire for increased health promotion and disease prevention to meet patient demands in medicine and dentistry stated. Works of numerous named and 'unnamed' authors credited for 'epidemiologic viewpoint' as a lens for framework development (Leavell and Clark 1958)	**Yes.** Personal experience with individual level physician-client relationship implicated as well as publications for framework development and explication, such as Sheps (1955), among others	**Yes.** Influences of the goals of Outcomes Measures and Care Delivery Systems invitational conference and work of Donabedian (1966), Holzemer & Reilly (1995), Wilson and Cleary (1995) acknowledged
Comprehensive-ness of Content	**Incomplete.** Nursing inputs/interventions not included in model	**Complete**. All nursing domains and relational propositions addressed, though not identified as such	**Complete.** All nursing domains and relational propositions addressed
Logical Congruence	**Yes**. Consistent with Reaction World View, person-environment and intervention categories of knowledge	**Yes.** Consistent with Reaction World View, outcomes and interventions category of knowledge	**Yes.** Consistent with Reciprocal World View, outcomes category of knowledge
Generation of Theory	**Yes.** Few examples in the literature that use the model to generate nursing theory	**Yes.** Numerous nursing publications use this framework to generate testable hypotheses	**Yes.** Multiple nursing publications use this framework to generate testable hypotheses
Legitimacy	**Mixed.** Few examples found of successful hypothesis testing in nursing, inspired creation of adapted nursing model (Reifsnider 1995)	**Mixed.** Model has been used to guide nursing research and practice successfully, but has also inspired creation of adapted nursing models (Mitchell et al. 1998, Shield et al. 2014)	**Yes.** Successful hypothesis testing published without limitations due to the model
Social Utility	**Moderate.** No education or skills required. Ability to implement protocols derived from model based on expert opinion (Zastrow 2011, Massanari 1989)	**High.** No education or skills required. Ability to implement protocols	**High.** No education or skills required. Ability to implement protocols
Social Congruence	**Unknown.** Usefulness across cultures and geographies not published in nursing	**High.** Cross-cultural/diverse geographic application published in nursing research (Chen et al. 2007, Closs and Tierney 1993)	**High.** Applied to nursing care among facilities in diverse geographic locations and with diverse patient demographics (Brooks-Carthon et al. 2011, Shang et al. 2014)
Social Significance	**High.** Versatility of model yields high applicability in diverse subjects and fields	**High.** Model is well-integrated into nursing research with high impact on practice	**High.** Model directed at nursing outcomes with significant influence
Contributions to Nursing Knowledge and nursing Discipline	**High.** Effective organizing framework though few papers identified using this model to generate theory	**High.** Breadth of model concepts yield broad applicability in nursing	**High.** Model has effectively guided nursing activities such as several report card initiatives

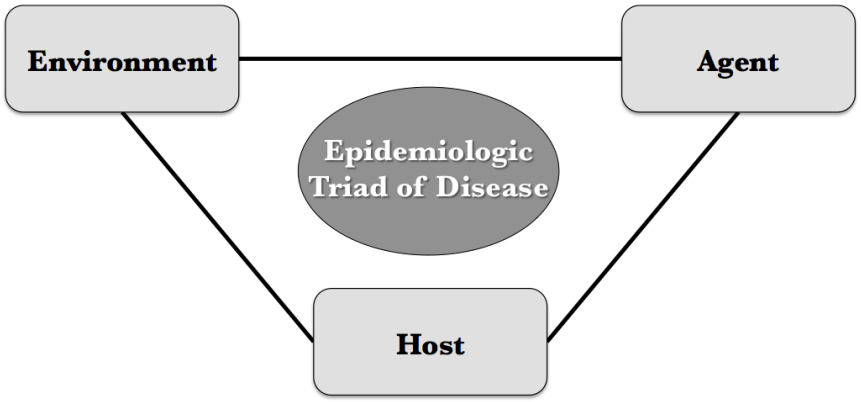

Figure 2. The Epidemiologic Triad of Disease (Clark 1954)

Figure 3. Donabedian's Quality Health Outcomes Framework.
Note: This model is sometimes depicted with a separate 'client characteristics' concept leading to/influencing 'processes' (Donabedian 1966).

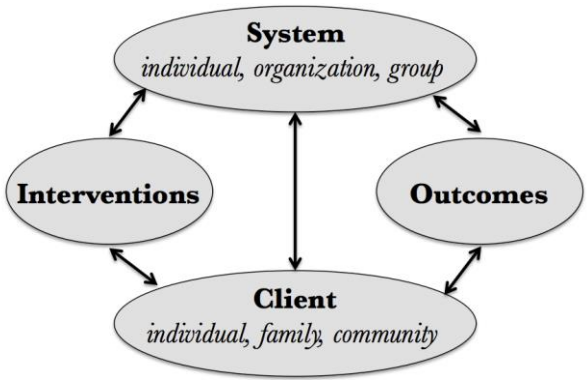

Figure 4. The Quality Health Outcomes Framework (Mitchell et al. 1998)